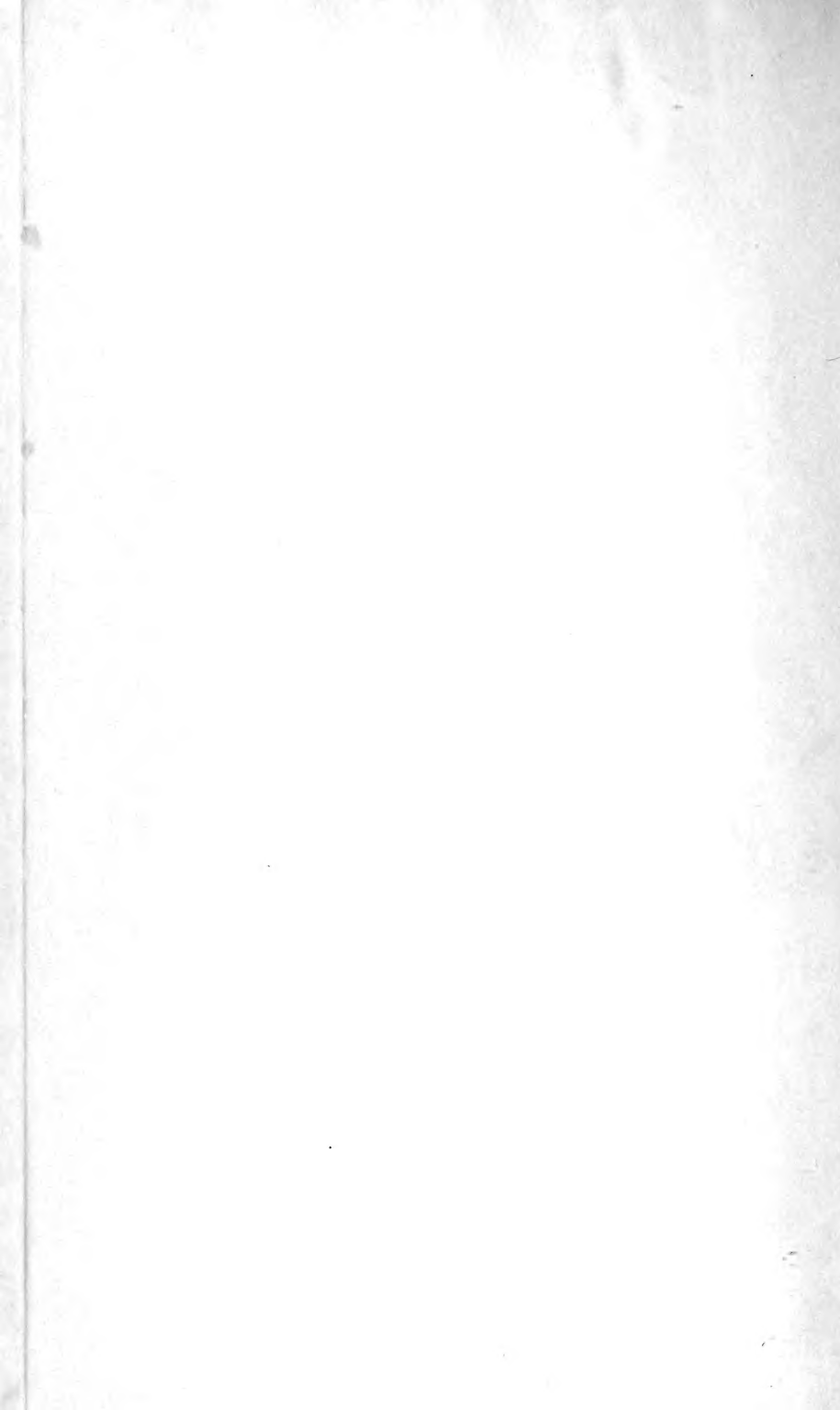




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93

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History of science
(EVERY-DAY SCIENCE)

BY
HENRY SMITH WILLIAMS, M.D., LL.D.

ASSISTED BY
EDWARD H. WILLIAMS, M.D.

KEY AND INDEX



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DEDICATION

To the boys and girls of to-day, who hold all the possibilities of the future in their keeping.

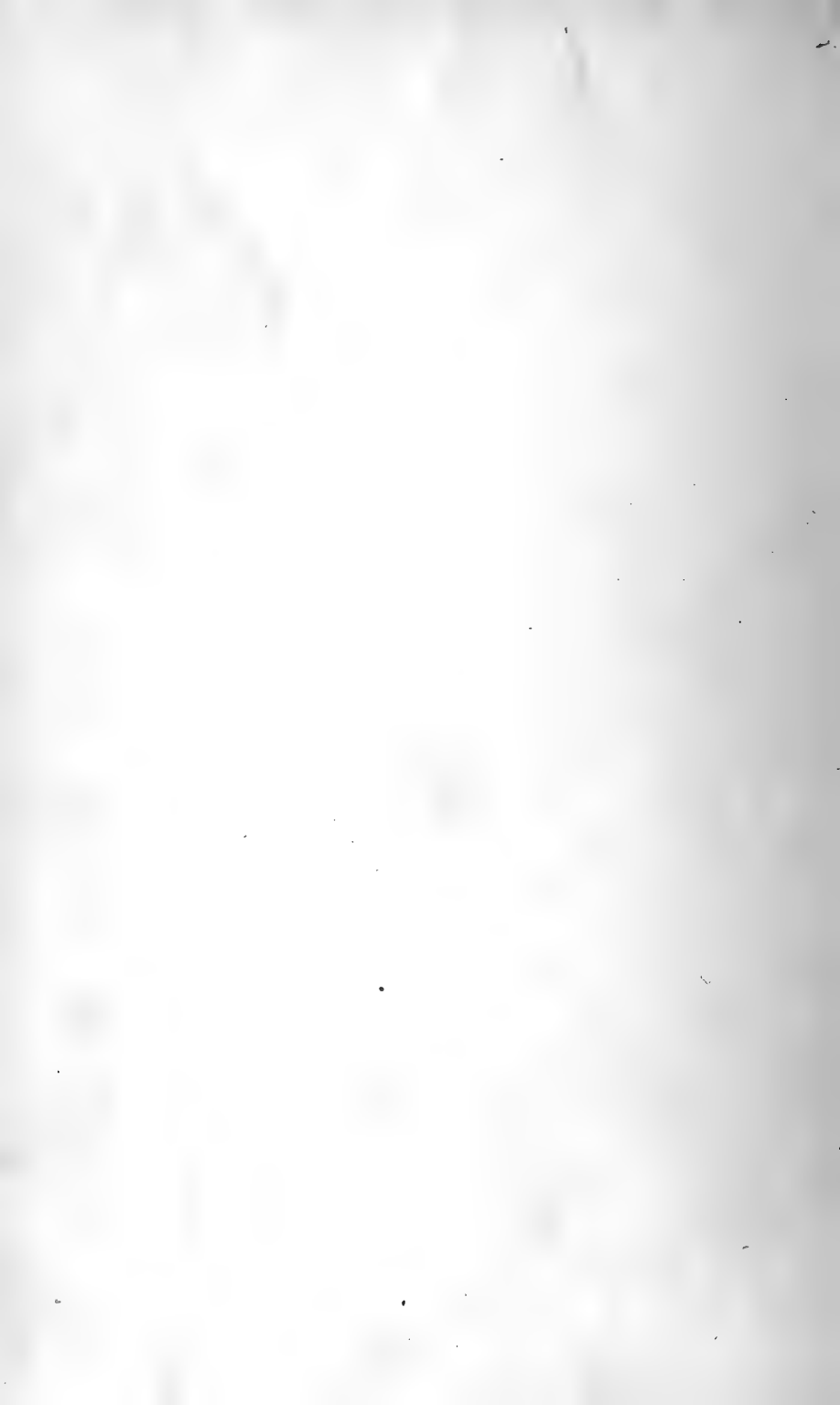
To mothers and fathers, upon whom rests the vast responsibility of directing the minds and moulding the characters of the coming generation;

To educators by profession in every rank from kindergarten to university;

To members of the traditional "learned" professions, who are of necessity leaders of thought and formulators of ideals in the community; and

To intelligent men and women in any walk of life who aspire to keep abreast of their times and to broaden their horizons:

The books of this series, designed to contribute to the progress of civilization through the dissemination of useful knowledge, are dedicated.



CONTENTS

- I. INTRODUCTION AND KEY, outlining the general scheme of the entire work and giving complete tables of contents by chapters.
- II. TECHNICAL INDEX AND GLOSSARY, in which the technical terms of every department of Science are defined, with illustrative comment.
- III. BIOGRAPHICAL INDEX, comprising a full list of the discoveries in every department of Science, theoretical and practical, with brief sketches of their work.
- IV. ENCYCLOPÆDIC GENERAL INDEX, covering fully all the topics treated, with abundant cross-references.



KEY AND INDEX VOLUME

A KEY TO THE TEXT

THE present volume is devoted to Indexes which analyze the text of the preceding volumes from various standpoints.

Two of these indexes are of somewhat novel character, inasmuch as they introduce specific explanatory matter concerning technicalities of science, or biographical data regarding important scientific workers, in addition to guiding the reader to the pages of the preceding volumes.

The third Index is of more conventional character, and is designed solely as an analysis of the text; yet its references are always so phrased as to convey a clear idea of the exact subject to which the reader is guided.

AN ANALYSIS OF THE TEXT

As preliminary to these Indexes it will, perhaps, be a convenience to the reader to have presented here a very brief analysis of the varied contents of the preceding volumes from two different standpoints: First, a very general survey of the subjects treated; secondly, a more detailed presentation of these subjects as revealed by the titles of the successive chapters, volume by volume.

Perhaps the most general analysis that could be made of the text as a whole would characterize it as a comprehensive presentation of the growth of scientific

KEY AND INDEX

knowledge in all its departments, and the application of that knowledge to the affairs of every-day life.

So general a characterization, of course, can convey but a vague impression to the mind. To make this impression somewhat specific, let us say that there are six or seven large groups of subjects that form the theme of our successive chapters. These might be summarized in various ways, but perhaps the following somewhat arbitrary classification will serve as well as another:

1. Cosmical Sciences, as specifically represented by the science of astronomy, with its practical applications to the art of navigation. Here we have to do with the ferreting-out of the secrets of the starry universe and the planetary systems, from the visionary interpretations of the ancient Egyptian and Babylonian stargazers to the accurately measured records of the modern observer, equipped with telescope, spectroscope, and photographic plate, or with sextant and compass.

2. Telluric Sciences; specifically, geography, geology, paleontology, and meteorology. Here we deal with those studies through which a knowledge of the earth's geographic masses and of its rocky structure has been gained; with interpretations of the method of world-building that have been made possible by the study of fossil remains; and with the investigations of atmospheric phenomena to which the modern practical science of weather prediction owes its origin and its success.

3. Physical Sciences, or what the students of the elder day termed natural philosophy, including the phenomena of gravitation, heat, light, sound, and electricity and magnetism. This is a field at once of the most obvious interest and the utmost practical importance. Not only do its studies have to do with

A KEY TO THE TEXT

the most familiar yet baffling and inscrutable of phenomena, but they deal also with the applications and transmutations of energy upon which practically all the mechanisms that perform the world's work depend—from water wheels and windmills to steam engines, gasoline motors, and electric dynamos.

4. Chemical Science, and the Chemical Industries. Here we have virtually an extension of the physical field to the world of the atom. We deal with inscrutable forces which have, nevertheless, the most tangible manifestations. Our studies range from the visionary dreams of the ancient alchemist, and the scarcely less mystical calculations of the modern student of atoms, valences, and periodic functions, to such highly practical fields as the work of electro-plating metals, compounding dye-stuffs, and manufacturing artificial gems in the laboratory.

5. Biological Sciences, including botany, zoology, biology proper, anatomy and physiology, medicine, experimental psychology, and anthropology. Here the very list of subjects is sufficiently explicative of the wide range of interests involved. We deal with the origins of life itself; with the evolution of species; with the applications of scientific knowledge to the conquest of disease; and with those subtle studies that are concerned with the brain itself and with the disembodied evidence of its functionings which we term the mind.

6. The Applied Sciences, or Mechanical Arts. Much that is implied by this title might properly be included, also, in the preceding ones. There are, however, a good many of the mechanical arts—for example, paper-making, printing, book-binding, the manufacture of cloth, the development of the flying-machine, and the like—that have depended for their development upon the ingenious application of familiar principles rather than upon any novel discovery. Yet

KEY AND INDEX

the story of the application of these principles is full of interest, and in many cases the ingenuity displayed in the application of old principles to new purposes is fully entitled to be described as the work of genius. Indeed such application of theoretical principles to the development of the practical mechanisms through which the entire structure of civilization has been developed constitutes the crowning achievement of scientific investigation.

CONTENTS BY CHAPTERS

The summary just presented will serve, perhaps, to give at least a general notion of the scope of our text. A notion still more precise may be gained from a survey of the contents of the successive volumes by chapters. Such a Table of Contents is here presented. By glancing at it the reader will be enabled to locate any specific subject as regards its main treatment. The list may, therefore, serve as an index of the most general character, preparatory for the detailed analyses made by the Indexes that follow, which are, as already noted, of three types:

I. Technical Index and Glossary, in which the technical terms of every department of science are defined, with illustrative comment.

II. Biographical Index: Comprising a full list of the discoverers in every department of science, theoretical and practical, with brief sketches of their work.

III. Encyclopædic General Index for the text volumes, covering fully all the topics treated, with abundant cross references.

It is unnecessary to characterize these indexes in detail, as their titles are in the main self-explanatory, and as the indexes themselves occupy the succeeding pages, making up the bulk of the present volume.

CONTENTS BY CHAPTERS

VOLUME I

THE BEGINNINGS OF SCIENCE

CHAPTER	PAGE
I. PREHISTORIC SCIENCE	3
II. EGYPTIAN SCIENCE	25
III. SCIENCE OF BABYLONIA AND ASSYRIA	56
IV. THE DEVELOPMENT OF THE ALPHABET	86
V. THE BEGINNINGS OF GREEK SCIENCE	103
VI. THE EARLY GREEK PHILOSOPHERS IN ITALY	112
VII. GREEK SCIENCE IN THE EARLY ATTIC PERIOD	139
VIII. POST-SOCRATIC SCIENCE AT ATHENS	178
IX. GREEK SCIENCE OF THE ALEXANDRIAN OR HELLENISTIC PERIOD	189
X. SCIENCE OF THE ROMAN PERIOD	253
XI. A RETROSPECTIVE GLANCE AT CLASSICAL SCIENCE	285
APPENDIX, NOTES, AND BIBLIOGRAPHY	301

VOLUME II

THE BEGINNINGS OF MODERN SCIENCE

I. SCIENCE IN THE DARK AGE	3
II. MEDIÆVAL SCIENCE AMONG THE ARABIANS	13
III. MEDIÆVAL SCIENCE IN THE WEST	31
IV. THE NEW COSMOLOGY—COPERNICUS TO KEPLER AND GALILEO	52
V. GALILEO AND THE NEW PHYSICS	93
VI. TWO PSEUDO-SCIENCES—ALCHEMY AND ASTROLOGY	124
VII. FROM PARACELSUS TO HARVEY	156
VIII. MEDICINE IN THE SIXTEENTH AND SEVENTEENTH CENTURIES	181
IX. PHILOSOPHER-SCIENTISTS AND NEW INSTITUTIONS OF LEARNING	191
X. THE SUCCESSORS OF GALILEO IN PHYSICAL SCIENCE	204
XI. NEWTON AND THE COMPOSITION OF LIGHT	225
XII. NEWTON AND THE LAW OF GRAVITATION	236
XIII. INSTRUMENTS OF PRECISION IN THE AGE OF NEWTON	252
XIV. PROGRESS IN ELECTRICITY FROM GILBERT AND VON GUERICKE TO FRANKLIN	259
XV. NATURAL HISTORY TO THE TIME OF LINNÆUS	297
APPENDIX, NOTES, AND BIBLIOGRAPHY	305

VOLUME III

MODERN DEVELOPMENT OF THE PHYSICAL SCIENCES

I. THE SUCCESSORS OF NEWTON IN ASTRONOMY	3
II. THE PROGRESS OF MODERN ASTRONOMY	19
III. THE NEW SCIENCE OF PALEONTOLOGY	74

CONTENTS BY CHAPTERS

CHAPTER	PAGE
IV. THE ORIGIN AND DEVELOPMENT OF MODERN GEOLOGY	116
V. THE NEW SCIENCE OF METEOROLOGY	168
VI. MODERN THEORIES OF HEAT AND LIGHT	206
VII. THE MODERN DEVELOPMENT OF ELECTRICITY AND MAGNETISM	229
VIII. THE CONSERVATION OF ENERGY	253
IX. THE ETHER AND PONDERABLE MATTER	283
APPENDIX, NOTES, AND BIBLIOGRAPHY	307

VOLUME IV

MODERN DEVELOPMENT OF THE CHEMICAL AND BIOLOGICAL SCIENCES

I. THE PHLOGISTON THEORY IN CHEMISTRY	3
II. THE BEGINNINGS OF MODERN CHEMISTRY	11
III. CHEMISTRY SINCE THE TIME OF DALTON	38
IV. ANATOMY AND PHYSIOLOGY IN THE EIGHTEENTH CENTURY	73
V. ANATOMY AND PHYSIOLOGY IN THE NINETEENTH CENTURY	102
VI. THEORIES OF ORGANIC EVOLUTION	140
VII. EIGHTEENTH-CENTURY MEDICINE	182
VIII. NINETEENTH-CENTURY MEDICINE	199
IX. THE NEW SCIENCE OF EXPERIMENTAL PSYCHOLOGY	245
X. THE NEW SCIENCE OF ORIENTAL ARCHÆOLOGY	287
APPENDIX, NOTES, AND BIBLIOGRAPHY	303

VOLUME V

ASPECTS OF RECENT SCIENCE

I. THE BRITISH MUSEUM	3
II. THE ROYAL SOCIETY OF LONDON FOR IMPROVING NATURAL KNOWLEDGE	14
III. THE ROYAL INSTITUTION AND THE LOW-TEMPERATURE RESEARCHES	29
IV. SOME PHYSICAL LABORATORIES AND PHYSICAL PROBLEMS	73
V. THE MARINE BIOLOGICAL LABORATORY AT NAPLES	113
VI. ERNST HAECKEL AND THE NEW ZOOLOGY	144
VII. SOME MEDICAL LABORATORIES AND MEDICAL PROBLEMS	178
VIII. SOME UNSOLVED SCIENTIFIC PROBLEMS	203
IX. RETROSPECT AND PROSPECT	230
REFERENCE LIST AND LIST OF SOURCES	243

CONTENTS BY CHAPTERS

VOLUME VI

THE CONQUEST OF NATURE

CHAPTER	PAGE
I. MAN AND NATURE	3
II. HOW WORK IS DONE	29
III. THE ANIMAL MACHINE	43
IV. THE WORK OF AIR AND WATER	62
V. CAPTIVE MOLECULES: THE STORY OF THE STEAM ENGINE	79
VI. THE MASTER WORKER	110
VII. GAS AND OIL ENGINES	132
VIII. THE SMALLEST WORKERS	148
IX. MAN'S NEWEST CO-LABORER—THE DYNAMO	171
X. NIAGARA IN HARNESS	183
XI. THE BANISHMENT OF NIGHT	201
XII. THE MINERAL DEPTHS	242
XIII. THE AGE OF STEEL	271
XIV. SOME RECENT TRIUMPHS OF APPLIED SCIENCE	298
APPENDIX	321

VOLUME VII

THE CONQUEST OF TIME AND SPACE

I. THE CONQUEST OF THE ZONES	5
II. THE HIGHWAY OF THE WATERS	56
III. SUBMARINE VESSELS	93
IV. THE STEAM LOCOMOTIVE	119
V. FROM CART TO AUTOMOBILE	152
VI. THE DEVELOPMENT OF ELECTRIC RAILWAYS	175
VII. THE GYROCAR	195
VIII. THE GYROSCOPE AND OCEAN TRAVEL	217
IX. NAVIGATING THE AIR	226
X. THE TRIUMPH OF THE AEROPLANE	272
APPENDIX	303

VOLUME VIII

SCIENCE IN THE INDUSTRIAL WORLD

I. THE DEVELOPMENT OF THE TELEGRAPH	3
II. THE SUBMARINE CABLE	30
III. WIRELESS TELEGRAPHY	47
IV. THE DEVELOPMENT OF THE TELEPHONE	66
V. THE EDISON PHONOGRAPH	93
VI. PRIMITIVE BOOKS	99
VII. THE PRINTING AND MAKING OF MODERN BOOKS	119
VIII. THE MANUFACTURE OF PAPER	159

CONTENTS BY CHAPTERS

CHAPTER	PAGE
IX. THE REPRODUCTION OF ILLUSTRATIONS	184
X. PHOTOGRAPHY IN ITS SCIENTIFIC ASPECTS	220
XI. PAINTS, DYES, AND VARNISHES	258
APPENDIX	323

VOLUME IX

INGENUITY AND LUXURY

I. AN INDUSTRIAL REVOLUTION	5
II. THE MANUFACTURE OF TEXTILES	38
III. THE STORY OF COSTUMES	58
IV. THE SEWING-MACHINE	87
V. CLOTHING THE EXTREMITIES	103
VI. THE EVOLUTION OF THE DWELLING HOUSE	133
VII. THE MODERN SKYSCRAPER	162
VIII. ARTIFICIAL STONE, OR CONCRETE	182
IX. FURNITURE AND FURNISHINGS	213
X. THE PRODUCTS OF CLAY AND FIRE	227
XI. GLASS AND GLASS-MAKING	277
XII. GEMS, NATURAL AND ARTIFICIAL	295
APPENDIX	333

VOLUME X

THE SCIENCE OF HAPPINESS

PART I.—THE PROBLEM OF HAPPINESS AND ITS PHYSICAL ASPECTS

I. THE PROBLEM OF HAPPINESS	5
II. PHYSICAL NEEDS	21
III. SOUND BODIES	41
IV. HOW TO SLEEP	61

PART II.—MENTAL ASPECTS OF THE PROBLEM OF HAPPINESS

V. HOW TO SEE AND REMEMBER	85
VI. HOW TO THINK	103
VII. THE WILL AND THE WAY	123
VIII. SELF KNOWLEDGE	135

PART III.—SOCIAL ASPECTS OF THE PROBLEM OF HAPPINESS

IX. HOW TO WORK	149
X. YOUTH VERSUS AGE	167
XI. GOLD VERSUS IDEALS	185
XII. VOCATION VERSUS AVOCATION	195

PART IV.—MORAL ASPECTS OF THE PROBLEM OF HAPPINESS

XIII. LIFE COMPANIONSHIP	213
XIV. THE COMING GENERATION	231
XV. HOW TO INVITE HAPPINESS	243
XVI. HOW TO DIE	257
APPENDIX AND INDEX	273 to 350

TECHNICAL INDEX AND GLOSSARY

(Under this alphabet, technical and semitechnical terms are defined, with illustrative comment, and often with the addition of historical data. The references to the text, by volume and page, though specific, are intended rather as general guides to the reader than as offering a complete or detailed analysis of the subject.

For a more detailed analysis see the Encyclopædic General Index in this volume. For biographical data see the Biographical Index.)

Aberration. (1) In physics, that property of a lens in virtue of which it forms an image with color fringes, due to the fact that different rays of light are not brought precisely to the same focus. This difficulty is never entirely overcome even with the finest astronomical lenses. (2) In astronomy, the displacement of the apparent position of a celestial body due to the fact that the velocity of light is not infinite. See "Bradley and the Aberration of Light," Vol. III, p. 11.

Abrasives. Those substances used in grinding and polishing. See "Gems, Natural and Artificial," Vol. IX, p. 295; in particular p. 306; also "Glass and Glass Making," Vol. IX, p. 293.

Absolute Zero. The hypothetical condition of matter at which its molecules or atoms are in such a state of quiescence that they give out no heat. Theoretically this point lies 272° below the Centigrade zero; practically it has not been demonstrated in the laboratory. See "The Royal Institution and the Low Temperature Researches," Vol. V, Chapter 3; in particular p. 69.

Acetylene. A hydrocarbon gas, made commercially by adding water to calcium carbide; it has the chemical formula C_2H_2 . See "The Introduction of Acetylene Gas," Vol. VI, p. 212.

Actinium. An element occurring in nature associated with zinc. Discovered in 1881 by Dr. T. L. Phipson. See "Element" and "Periodic Law," under present alphabet.

Aeroplane. The apparatus, consisting originally of a canvas plane or planes supported by poles and wires and actuated by motor-driven propellers, which constituted the first heavier-than-air machine in which human flight was accomplished. The

KEY AND INDEX

first successful aeroplane, that of the Wright Brothers (operated at Kitty Hawk, North Carolina, in December, 1903), had two chief planes, one above the other, and hence is called a biplane. The imitative machines of Farman, Curtiss, and Cody are also biplanes. The apparatus perfected by Blériot has a single chief plane, and is called a monoplane. The machine used by Hubert Latham is also a monoplane. The prototype of these machines is the original aerodrome of Langley, which was essentially a monoplane inasmuch as its two chief portions were arranged in the same horizontal plane. The box kite may be taken as the prototype of the biplane. See "The Triumph of the Aeroplane," Vol. VII, p. 272.

Air-pump. A machine by means of which air or other gases may be removed from an enclosed space. It was invented by Otto von Guericke about 1650. See "Mariotte and von Guericke," Vol. II, p. 210.

Air-thermometer. An instrument for measuring temperature, in which the change of volume of air under a constant pressure is made to indicate changes in temperature. The discovery that a gas expands at a uniform rate under increasing temperatures, and correspondingly contracts as temperatures decrease (constant pressure being maintained) was made independently by Boyle and Mariotte in the eighteenth century. See "The Successors of Galileo in Physical Science," Vol. II, p. 204 and p. 210.

Albinism. A condition in which there is a congenital absence of pigment in the hair, iris, and skin. It occurs in plants as well as animals, and in all races of men. Individuals so affected are called albinos. See the reference to the collection of specimens illustrating albinism (and the opposite state of melanism) in the Natural History Museum at South Kensington, London, Vol. V, p. 10.

Alchemy. The pseudo-science which sought to find a magic "elixir" or "philosophers stone" that would give its possessor the secret of eternal youth, and would also enable him to transmute silver and perhaps the baser metals into gold. For full treatment of the subject, see the chapter "Two Pseudo-Sciences—Alchemy and Astrology," Vol. II, p. 124.

Alcohol. The commercial name for ethyl alcohol, having the chemical formula $C_2H_5O H$. Alcohol results from the fermentation of sugars and starches, and is the intoxicating principle of wine and other beverages that were familiar from the earliest times; but the distilled spirit as such seems to have been dis-

TECHNICAL INDEX AND GLOSSARY

covered, or at all events introduced to the Western world and named by mediæval Arabian physicians. See "Mediæval Science Among the Arabians," Vol. II, p. 22.

Alizarine. A substance formerly obtained from the root of the madder plant, *Rubia tinctorum*, but now chiefly produced from coal-tar. It has great commercial importance as a dye, producing the color known as "turkey red." The growth of the madder plant was formerly an important industry, but like the cultivation of the indigo plant, this pursuit has been made superfluous by the cheapness of the coal-tar colors. See "Pigments from Vegetable and Animal Sources," Vol. VIII, p. 302; in particular pp. 307-309.

Alloy. An intimate homogeneous mixture of different metals, usually produced by fusion. Thus brass is an alloy of copper and zinc; pewter, an alloy of tin and lead; steel, an alloy of iron and various other elements, chief among which are carbon, nickel, manganese, and tungsten. See chapter "The Age of Steel," Vol. VI, p. 271; in particular "The Conversion of Iron Ore into Iron and Steel," p. 283, and "Alloy Steels," p. 295.

Alternating current. The electrical current produced by a dynamo not provided with a commutator. See "The Mechanism of the Dynamo," Vol. VI, p. 173.

Aluminum. A nearly white metal, about as hard as silver, and having a tensile strength about equal to that of copper, but many times lighter in weight than either. It alloys with almost all the metals, and for this reason, and because of its lightness, is of great commercial importance. Aluminum oxides are the base of the important corundum group of gems, including true rubies, sapphires, and emeralds. See "The Ruby and Its Allies," Vol. IX, p. 319; also "Artificial Gems," Vol. IX, p. 331. Though aluminum is a chief constituent of clayey soils, its isolation has been difficult. For the electrolytic method of its production, see "Some Recent Triumphs of Applied Science," Vol. VI, p. 300.

Amethyst. A variety of corundum (a crystalline oxide of aluminum), its violet or purple color being due probably to traces of manganese or of iron. See "The Ruby and its Allies," Vol. IX, p. 319.

Ammonia. A gaseous compound of hydrogen and nitrogen, having the formula NH_3 . It is supposed to derive its name from the fact that it was originally prepared near the temple of Ammon, in Egypt. Its composition was, of course, unknown until the time of the "pneumatic chemists" (including Black,

KEY AND INDEX

Cavendish, Priestley, Scheele, and Lavoisier), whose efforts laid the foundation for all modern knowledge of the gases about the close of the eighteenth century. For an account of their work, see "The Beginnings of Modern Chemistry," Vol. IV, p. 11.

Amoeba. A protozoan, which is present almost everywhere in fresh water, and in moist earth, and is usually taken as a type of unicellular animals. Certain forms of the Amoeba produce diseases, such as dysentery and abscess of the liver. Microscopic organisms were studied by such early microscopists as Leeuwenhoek (see Vol. II, p. 179) and Robert Hooke (see Vol. II, p. 217), but it remained for investigators of the nineteenth century to demonstrate their importance. See "Parasitic Diseases," Vol. IV, p. 204.

Anaesthetic. An agent used to produce loss or impairment of sensibility. The word was coined by Dr. Oliver Wendell Holmes. The use of ether, the most important general anaesthetic known, was discovered by Dr. W. T. G. Morton, a dentist, in 1842. The anaesthetic property of chloroform was discovered by Sir. J. Y. Simpson, of Edinburgh, in 1843. See "Painless Surgery," Vol. IV, p. 208.

Anastomosis. In anatomy, the joining of branches of a vessel with other vessels or branches. Hunter's discovery of the function of this anastomosis in arteries and veins marked an epoch in surgery. See Vol. IV, p. 82.

Aneurism. A disease (or injury) of the walls of an artery resulting in the formation of a pulsating tumor or sac. The English surgeon, John Hunter, about 1770, devised an operation for the cure of this condition, his discovery being the direct result of an operation performed on a deer in Richmond Park. See "Hunter's Operation for the Cure of Aneurism," Vol. IV, p. 81.

Aniline. An organic substance, with the formula $C_6H_5NH_2$. It was discovered in 1826, but was of no commercial importance until 1856, when W. H. Perkin prepared a purple dye from it. See "Coal-tar Colors," Vol. VIII, p. 311.

Animism. A system of philosophy introduced by Stahl, based on the idea that the soul is the seat of life. See "Eighteenth Century Medicine," Vol. IV, p. 185.

Annealing. A process for increasing the ductility of metals and glass. The usual method of annealing is by heating and then cooling slowly.

Anode. The electrode at which a current of positive electricity enters a battery. The other electrode is called the "cathode."

TECHNICAL INDEX AND GLOSSARY

Anthrax. A disease affecting cattle, sheep, and men, known as malignant pustule, splenic fever, wool-sorter's disease, etc. It is very fatal, and caused by the bacillus anthracis. Protection by preventive inoculation was discovered by Pasteur. See Vol. IV, p. 232.

Anthropology. The branch of knowledge that deals with the characteristics of mankind as forming an organic whole. It considers the question of man's first appearance on earth, and the influences that have resulted in existing civilization. Scientific anthropology is a development of the late nineteenth century, the discoveries that proved man's antiquity preparing the way. See "Fossil Man," Vol. III, p. 98; also "The New Science of Anthropology," Vol. V, p. 228.

Antipyritics. The name given to those remedies used for reducing temperature in diseased conditions.

Antiseptic. A term meaning that which arrests decay. In modern medicine a substance which destroys disease-producing micro-organisms, or germs. The discovery of the use of antiseptics in surgery was made by Lord Lister, this discovery and its application bringing about a revolution in surgical methods. See "Lister and Antiseptic Surgery," Vol. IV, p. 229.

Antitoxins. Substances developed in the human body, or the body of an animal, antagonistic to the poisons (toxins) of disease. See "Serum Therapy," Vol. IV, p. 240; "Aims and Objects of the Pasteur Institute," Vol. V, p. 182.

Archæology. The science that deals with the history of human progress in ancient times, as judged by relics of man's work, apart from written records. See "The New Science of Oriental Archæology," Vol. IV, p. 287.

Argon. An element discovered in the earth's atmosphere by Sir William Ramsay and Lord Rayleigh. Named from the Greek word meaning "inactive," because of its lack of chemical affinity. See "Sir William Ramsay and the New Gases," Vol. V, p. 82; in particular pp. 85-86.

Armature. The name given originally to a piece of soft iron placed across the poles of permanent or electro-magnets to receive and concentrate the attractive force. In the modern dynamo, the armature consists of coils of wire which convey an electric current. The mutual relations of armature and electro-magnet (either of which may revolve, but one or the other being stationary) give rise to the accentuated electrical

KEY AND INDEX

current which it is the function of the dynamo to develop. See "The Mechanism of the Dynamo," Vol. VI, p. 173; also "Niagara in Harness," Vol. VI, p. 190.

Artificial Gems. See "Gems," in present glossary.

Artificial Stone, or Concrete. A stone-like substance made by mixing cement with sand and pebbles or broken stone. Cement itself is a mixture of powdered burnt clay, and powdered hydrates of lime. It was extensively used by the Romans, but little used by their successors until toward the close of the nineteenth century. Modern cements differ somewhat from the ancient and from one another, but all have as a base a mixture of argillaceous and calcareous minerals (clays and lime compounds). See chapter on "Artificial Stone, or Cement," Vol. IX, p. 182.

Astrolabe. An obsolete instrument for measuring the apparent angle between two visual (usually astronomical) bodies. The astrolabe, introduced about the middle of the fifteenth century, superseded the cross-staff as an aid to the navigator, and was in due course supplanted by the sextant. See "The Development of the Sextant," Vol. VII, p. 18.

Astrology. The pseudo-science that purports to study the stars and planets with the intent to forecast or interpret terrestrial events. Astrology flourished in Egypt and Babylonia and in the Western world throughout the Middle Ages. It numbered among its practitioners some astronomers of note, after the revival of learning, even including Kepler, who, however, was probably skeptical as to the validity of its claims. It gradually fell into disrepute with the advance of scientific knowledge. See "Two Pseudo-Sciences," Vol. II, p. 141.

Astronomy. The science that deals with the sidereal and planetary bodies. Observational astronomy reached a relatively high development in Egypt and Babylonia and was cultivated with great success by the Greeks of the Alexandrian epoch. The Arabs were adept star-gazers. But modern astronomy dates from Copernicus, Kepler, Galileo, and Tycho Brahe. The vast generalization of Newton gave it fresh impetus. Herschel's perfected telescope opened up new fields, with particular reference to nebulae and double stars. Spectroscopy and photography in the nineteenth century still further widened the scope of the science. See "Egyptian Astronomy," Vol. I, p. 33; "Babylonian Astronomy," Vol. I, p. 61; for Greek Astronomy, Vol. I, p. 212; "Ptolemy, the Last Great Astronomer of Antiquity," Vol. I,

TECHNICAL INDEX AND GLOSSARY

p. 267; *Arabian Astronomy*, Vol. II, p. 14; "Copernicus to Kepler and Galileo," Vol. II, p. 52; "Newton and the Law of Gravitation," Vol. II, p. 236; "The Successors of Newton in Astronomy," Vol. III, p. 3; "The Progress of Modern Astronomy," Vol. III, p. 19; "Solar and Telluric Problems," Vol. V, p. 205. Numerous minor references might be added, but the above outline the main story of astronomical progress.

Atlantic Cable. The first cable across the Atlantic was projected by Cyrus W. Field in 1856. After unsuccessful efforts, the first electric message was sent across the ocean in August, 1858. This cable soon parted, however, and a permanent connection was not established till 1866. See "The Submarine Cable," Vol. VIII, p. 30.

Atmosphere. The "ocean of air in which we live" has been investigated scientifically chiefly within the past century. Its composition, as regards the chief constituents, oxygen and nitrogen, was determined toward the close of the eighteenth century; but the minor gases, argon, neon, crypton, and xenon, escaped detection for about a hundred years, when they were discovered by Lord Rayleigh and Sir William Ramsay. See Vol. V, p. 82. For meteorological aspects of the atmosphere, see Vol. III, p. 168.

Atom. The unit structure of matter as viewed by the chemist. The atomic theory of matter in its modern scientific development dates from the time of John Dalton, who propounded the theory in 1803. See "John Dalton and the Atomic Theory," Vol. IV, p. 38.

Atomic weights. Each specific atom has a definite weight, which chemists have been at great pains to discover. For table of atomic weights, see "Element," in the present glossary.

Aurora Borealis. A manifestation of lights seen at irregular intervals toward the polar regions; believed to be of electrical origin. The most recent explanation of the phenomenon is that of Arrhenius, who thinks the light due to electrons thrown out from the sun and accumulated in the upper atmosphere, where, under magnetic influence, they tend to move toward the poles. See "The Aurora Borealis," Vol. III, p. 172.

Automatic Coupling. A life and limb saving device for coupling freight cars without the direct intervention of human hands. An effective coupler was introduced by Eli Janney in 1879. See "Automatic Couplings," Vol. VII, p. 147.

Automobile. The familiar self-propelled vehicle, actuated

KEY AND INDEX

usually by a gasoline engine, but sometimes by steam or by electricity, sprang into popularity in the last decade of the nineteenth century, but its prototypes (propelled by steam) were made more than a hundred years earlier. See "The Coming of the Automobile," Vol. VII, p. 156.

Axe. This familiar implement is essentially a sharp wedge operated at the end of a lever. Its use dates from the Rough Stone Age. See "Applications of Muscular Energy," Vol. VI, p. 52.

Babylonian Medicine. The practice of medicine in Babylonia-Assyria was closely bound up with astrology and magic; yet it had certain more scientific aspects. See "Chaldean Magic," Vol. I, p. 69, and "Babylonian Medicine," Vol. I, p. 75.

Babylonian Science. The science of the Chaldeans, Babylonians, and Assyrians is usually somewhat vaguely included under this title. Our knowledge of the subject depends partly upon Greek traditions (Herodotus, Diodorus), and partly upon recently exhumed archæological remains. See "Science of Babylonia and Assyria," Vol. I, p. 56.

Bacteria. Microscopic vegetable organisms, which play an all-important part in the economy of nature, causing putrefactive changes, contagious diseases, etc. Discovered by Leeuwenhoek in 1683. Their real importance was unsuspected until late in the nineteenth century. For the importance of the part played by bacteria in surgery, and the discovery of a method of combatting their effect, see "Lister and Antiseptic Surgery," Vol. IV, p. 229. For recent studies in pathogenic bacteria, see "Some Medical Laboratories and Medical Problems," Vol. V, p. 182.

Barometer. An instrument for measuring the weight of the atmosphere; in its simplest form, a vacuum tube closed at one end and inverted over a dish of mercury; the height to which the mercury rises in the tube demonstrates the atmospheric pressure, which varies with the altitude and with the amount of moisture in the air. Invented by Torricelli in 1643. See "Torricelli," Vol. II, p. 120; also Pascal's test of the barometer by ascending a mountain and noting the lowering of the column of mercury, see Vol. II, p. 122.

Bicycle. A familiar two-wheeled vehicle, the most primitive form of which (termed the hobby horse) was introduced by Baron Von Drais in France about the year 1818. The halting stages by which the machine was perfected illustrate the rarity

TECHNICAL INDEX AND GLOSSARY

of creative imagination. See "From Cart to Automobile," Vol. VII, p. 152.

Biograph. An apparatus for producing "moving pictures," familiar under various names. The germ of the instrument was invented as long ago as 1833, but the developed apparatus came into being late in the nineteenth century. For the story of its development, see "Chrono-photography," Vol. VIII, p. 248.

Biology. A generic name for the sciences that deal with living things, including botany, zoology, physiology, in their various departments, and in the widest interpretation, medicine, anthropology, and ethnology. The word biology was introduced independently by Lamarck and Trevirans early in the nineteenth century, but did not come at once into general use. See "Schleiden and Schwann and the Cell Theory," Vol. IV, p. 118. For the work of Lamarck, Goethe, Darwin, and others, see "Theories of Organic Evolution," Vol. IV, p. 140.

Blast Furnace. A furnace for smelting ores, so called because of the blast of air forced through the furnace to promote combustion by bringing oxygen in contact with the fuel; or through the molten metal itself, as in the manufacture of steel. See "The Conversion of Iron Ore into Iron and Steel," Vol. VI, p. 283.

Blood Corpuscles. Microscopic cells that float in the blood and perform functions absolutely essential to the life of the organism. The red blood corpuscles are the carriers of oxygen; the white corpuscles, of several types, are scavengers, attacking and consuming noxious bacteria. For a description of the discovery of the course of circulation of the blood, and the final demonstration of the corpuscles passing through the capillaries, see "The Coming of Harvey," Vol. II, p. 169. For an explanation of the function of blood corpuscles, see "Blood Corpuscles, Muscles, and Glands," Vol. IV, p. 135.

Brain. In general terms, that part of the cerebrospinal axis which is contained in the cranium. For functions of, see "The New Science of Experimental Psychology," Vol. IV, p. 245.

Bronze. A compound of metals, having copper for its base, the other ingredient being usually tin. The proportion of copper in various bronzes is usually between 80 and 90 per cent. Copper melts at a temperature a little below that of gold, and the ease with which it is smelted led (as is believed) to its use long before the art of smelting iron had been acquired.

KEY AND INDEX

Calcium Carbide. A compound of calcium and carbon (Ca C_2), produced in the electric furnace by heating a mixture of lime and coke. When brought in contact with water, a chemical recombination is effected whereby acetylene gas (C_2H_2) is produced. The change is chemically expressed thus: $\text{Ca C}_2 + \text{H}_2\text{O} = \text{C}_2\text{H}_2 + \text{Ca O}$. See "The Introduction of Acetylene Gas," Vol. VI, p. 212.

Calotype Process. A photographic process invented by Fox Talbot (q. v.); the prototype of modern paper-printed photographs, as distinguished from the metallic-surface process of Daguerre. See "Talbot's Calotype Process," Vol. VIII, p. 227.

Camera Lucida. An instrument in which, through the use of prisms, light is refracted and reflected in such a way as to throw the image of a landscape or other view on a ground-glass plate, where its outlines may be readily sketched.

Camera Obscura. Essentially, as its name implies, a dark chamber, into which a single ray of light is admitted through a pinhole aperture. The small aperture has the effect of a lens, and an image of the scene outside is thrown on the wall of the chamber opposite the aperture. The photographic camera is a modified camera obscura, in which the light is focused by a lens. It is possible to take a photograph, of rather vague outline, by using a very small aperture, without a lens.

Candle. This familiar modified form of lamp, consisting essentially of a wick embedded in a solid cylinder of wax, tallow, or other easily liquefied, inflammable fat, was invented late in the twelfth century. For centuries it was the best of lighting apparatuses, and it has by no means been supplanted altogether even in our day. For the general description of methods of illumination, past and present, see "The Banishment of Night," Vol. VI, p. 201.

Carbonic Acid Gas. A compound of carbon and oxygen, having the formula CO_2 . It is given off through the lungs by animal organisms, and is absorbed by plants, which thus secure the carbon that enters so importantly into the vegetable structure. Another and still more poisonous compound of carbon oxygen is known as carbonic oxide (CO). Both these gases are sometimes present in mines. See "Conditions to be Considered in Mining," Vol. VI, p. 247, and "The Function of Respiration," Vol. IV, p. 92.

Cathode Rays. A peculiar manifestation of energy due to passing an electrical current through a vacuum tube. These rays cast a shadow and are deflected by a magnet; and, by im-

TECHNICAL INDEX AND GLOSSARY

ping on the glass receptacles, they generate X-rays. See "Professor J. J. Thomson and the Nature of Electricity," Vol. V, p. 92, for the investigations of Crookes, Leonard, Röntgen, Becquerel, Thompson, and others.

Cell. (1) The unit structure of living tissues. See Vol. IV, p. 115, for the investigations of Brown, Schleiden, Schwann, Von Mohl, and Virchow; also "The Mechanism of the Cell," Vol. V, p. 225. (2) The unit structure of a galvanic battery as devised originally by Galvani and Volta. See "Electricity," of the present index.

Centrosome. A minute structure (discovered by Van Beneden) within the organic cell, the precise function of which is in doubt.

Chemical Affinity. A term designating the attractive and selective influence that operates between chemical substances. The preference of the various chemical atoms are perfectly definite and unvarying, under given conditions, and the entire science of chemistry is built upon the knowledge of such interrelations between the different elementary atoms; but this knowledge is, in each case, matter of experimental observation. See "Chemical Affinity," Vol. IV, p. 57.

Chemistry. The science that deals with the interrelations of the different kinds of matter, as regards their elementary or atomic structure. The border-line between chemistry and physics is not always quite sharply defined (as, for example, in the matter of radio-activity, which encroaches upon both domains), but in general chemistry deals with atoms themselves; physics with the aggregations of atoms which we call molecules. Thus it was the province of the chemist to determine that water is a compound of hydrogen and oxygen, and that air is a mixture of nitrogen, oxygen, and other gases; while the study of such things as hydrostatic pressure, the expansion of gases, etc., belongs to the physicist. See "The Beginnings of Modern Chemistry," Vol. IV, p. 11, and "Chemistry Since the Time of Dalton," Vol. IV, p. 38.

Chimney. This seemingly essential architectural element of the dwelling-house was not known in antiquity, but was developed in the Middle Ages, or at the beginning of the modern period. See Vol. IX, p. 150.

China. A name applied to various kinds of glazed pottery, the exact implications of the word not being very closely defined. See "The Products of Clay and Fire," Vol. IX, p. 227.

Chisel. This familiar implement for gouging and cutting wood,

KEY AND INDEX

indispensable to the carpenter, is really a sharp-edged wedge, and operates on the principle of the inclined plane. It has been used, practically unmodified, from a very early period.

Chloroform. A compound prepared by cautiously distilling together a mixture of alcohol, water, and chloride of lime. Chemical symbol CHCl_3 . The use of chloroform as an anæsthetic was introduced by the Scottish surgeon, Sir J. Y. Simpson; not, however, until the anæsthetic power of ether had been clearly demonstrated by Morton in America. See "Painless Surgery," Vol. IV, p. 208.

Choke-damp. A colloquial name for carbonic acid gas (CO_2) when found in mines. The name is used (in contradistinction to the explosive "fire-damps") because this gas is non-explosive, but may cause death by asphyxiation—literally choking the miner to death. See "Conditions to be Considered in Mining," Vol. VI, p. 247.

Chromosomes. Minute, usually thread-like structures within the organic cell nucleus, which have peculiar interest because their number varies in different animals, but is always the same for each cell of any given species. The chromosomes are bisected when the cell divides. See pp. 131-134 of Vol. V for recent researches in this field.

Chronometer. Generically, any time-measurer; but specifically a name for the nautical watch or clock carried in duplicate or triplicate by navigators and explorers, which records the time at a given meridian (usually that of Greenwich), thus supplying information with the aid of which the navigator may compute his longitude from sidereal observations. See "Perfecting the Chronometer," Vol. VII, p. 23.

Chrono-photography. Generic name applied to the method of taking series of photographs at brief intervals, to the end that "moving pictures" may be produced. The apparatuses with which these pictures are reproduced are familiar under the trade names of kinetoscope, biograph, vitascope, etc. Names of Muybridge, Marey, Anschütz, and Edison are associated with the invention. See "Chrono-photography—Moving Pictures," Vol. VIII, p. 248.

Circuit. The medium or mediums connecting the poles of a battery or other generator of electricity. The ground, or a body of water, may serve as the medium of the so-called "return circuit"; but some conducting medium must give unbroken communication (however circuitous the route) or the current will

TECHNICAL INDEX AND GLOSSARY

not "flow." See "The Experiments of Stephen Gray," Vol. II, p. 262; "The Transmission of Power," Vol. VI, p. 194.

Civilization. Name somewhat loosely applied to the most recent stage of ethnical development, in contradistinction to "savagery" and "barbarism." In the terminology of some ethnologists, the word "civilized" is reserved for peoples that have acquired the art of writing.

Clock. The modern apparatus bearing this name is usually actuated either by weight and pulley, by pendulum, or by coiled springs. The most familiar type, the pendulum clock, was invented by Huyghens in 1656. The clypsedra, or water clock, was the most usual time-measurer throughout antiquity. See "Instruments of Precision in the Age of Newton," Vol. II, p. 256.

Coal-tar Colors. Pigments of an almost infinite variety of colors and shades of color produced from the distillation products of coal-tar, the basal form of which is known as aniline. The first commercially important aniline color was produced by Perkin in 1856. In recent years, coal-tar colors have revolutionized the indigo and alizarine industries. See "The Coal-tar Colors," Vol. VIII, p. 311.

Coherer. A very delicate instrument, in the original Marconi system, consisting essentially of brass filings in a vacuum tube, with the aid of which the Hertzian waves used in wireless telegraphy are detected. Coherers were invented independently by Prof. D. E. Hughes (1880) and Dr. Branly (1890-91). See "Wireless Telegraphy," Vol. VIII, p. 52.

Cohesion. The property in virtue of which bodies tend to hold together. The precise nature of this inter-molecular force is not clearly established; it may be identical with gravitation.

Collodion-emulsion Process. A photographic process dependent upon the use of sensitized emulsion, the basis of which is collodion. The process was introduced by Bolton and Sayce in 1864, and gave a new impetus to photography. Subsequently, gelatine was very generally substituted for collodion in making the emulsion. See "Photography in its Scientific Aspects," Vol. VIII, p. 231.

Color-photography. The attempt to reproduce the natural colors photographically has enlisted the efforts of a large number of experimenters, but as yet has met with only partial success, although very beautiful glass "positives" may now be made with comparative ease by the Lumière "autochrome" process. See "Photographing in Natural Colors," Vol. VIII, p. 234.

KEY AND INDEX

Comet. See "The Progress of Modern Astronomy," Vol. III, p. 19; in particular p. 38.

Compound Engine. A steam engine in which the steam, after acting on a piston in one cylinder, escapes, not into the air, but into another cylinder, where it acts on a second piston. A third and fourth cylinder may be added (triple and quadruple expansion). The compound engine was invented by Hornblower in 1784. See "Compound Engines," Vol. VI, p. 117.

Conservation of Energy. See "Energy."

Cordite. A compound having great explosive energy. It is composed of 58 parts of nitroglycerine, 37 parts of guncotton, and 5 parts vaseline. It was patented by Sir F. A. Abel and Professor (now Sir James) Dewar, of England.

Cosmology. The system of the universe or cosmos, as variously interpreted by successive generations of astronomers and philosophers. The cosmological system of the Egyptians and Babylonians were fantastic; those of the later Greeks and Romans (see Ptolemy) conceived the earth as the central body; the true (helio-centric) theory dates from Copernicus. For the cosmological system of the Egyptians, see "Ideas of Cosmology," Vol. I, p. 41. For that of the Babylonians, see "Babylonian Astronomy," Vol. I, p. 61. For the true theory, see "The New Cosmology," Vol. II, p. 52.

Cotton Fabrics. Fabrics made of threads spun from fibers of the seed-pod of the cotton plant. Cotton fabrics of great delicacy of texture have been made in India from the earliest times. A revolution in the cotton spinning and weaving industries was brought about, toward the close of the eighteenth century, through the inventions of Hargreaves, Arkwright, Crompton, the Kays, Cartwright, and Jacquard. See "An Industrial Revolution," Vol. IX, p. 6; and "The Manufacture of Textiles," Vol. IX, p. 38.

Cotton-gin. An apparatus for separating the seeds from the cotton fiber, invented in 1793 by Eli Whitney; it effected a virtual revolution in the cotton-raising industry. See "Eli Whitney and the Cotton-gin," Vol. IX, p. 8.

Crane. An apparatus (otherwise known as a derrick) for hoisting heavy bodies with the aid of ropes and pulleys, actuated sometimes by hand, sometimes by horse power, or steam, or electricity. In its primitive form it has been used from the earliest historical period. See "Archimedes of Syracuse and the

TECHNICAL INDEX AND GLOSSARY

Foundation of Mechanics," Vol. I, p. 196; and **"Inclined Planes and Derricks,"** Vol. IX, p. 37.

Cross-staff. A primitive apparatus for measuring the angle between two visual objects, such as two stars, or a star and the horizon-line. It was used by navigators from an early period, but was ultimately superseded by astrolabe (fifteenth century) and quadrant (eighteenth century). See **"The Development of the Sextant,"** Vol. VII, p. 18.

Crowbar. A simple lever, which, now made of iron or steel instead of wood, performs the same service for the modern workman that it did for his prehistoric ancestor.

Cupping-glass. A glass cup, which becomes a suction apparatus through the exhaustion of air within it; much used by physicians in the days when venesection was in vogue, but now practically obsolete.

Cyclone. A revolving atmospheric current, describing a circle that may be a few feet or many miles in diameter. The universality of cyclonic air currents was first prominently taught by H. W. Dove, about 1827. See **"Cyclones and Anti-cyclones,"** Vol. III, p. 199.

Daguerreotype. The form of photograph (using a metal surface, and giving a reversed image) invented by Louis J. M. Daguerre about 1839. The process is still much employed for the cheap photographs called tin-types. See **"Photography in its Scientific Aspects,"** Vol. VIII, p. 224.

Darwinian Theory. The theory of evolution (which owed its development to Charles Darwin, though independently conceived by Alfred Russell Wallace), which explains organic evolution as due in a large measure to the preservation of favorable varieties or stocks through "natural selection." The essentials of the theory, stated in a phrase, are spontaneous (i.e., unexplained) variation, and (in Herbert Spencer's phrase) the "survival of the fittest." Perhaps no other theory in the entire history of thought ever had so important an influence on the ideas of a generation as this theory exercised. See **"Theories of Organic Evolution,"** Vol. IV, p. 140.

Derrick. See Crane.

Diamond Drill. A drill for boring through rock, the cutting edge being made of a ring of black diamonds. See **"The Mineral Depths,"** Vol. VI, p. 247, and **"Other Sources of Diamonds; Practical Uses,"** Vol. IX, p. 317.

KEY AND INDEX

Direct Current. A current of electricity generated by a dynamo provided with a system of commutators through which the electric impulses are made to flow in one direction, instead of oscillating as they do in the so-called alternating current. For fuller information see the subject "Electricity," and its various departments.

Dissipation of Energy. See Energy.

Dissociation. A hypothetical chemical process (so named by Ste. Claire Deville), according to which the chemical atoms in any compound are constantly separating and reuniting. See "Chemical Affinity," Vol. IV, p. 57.

Ductless Glands. Certain glands in the animal body that have no excretory ducts, their functions being performed through the channels of the vascular and lymphatic vessels. The spleen, the thyroid gland, and the supra-renal capsules are important examples of this type of gland. See "Blood Corpuscles, Muscles, and Glands," Vol. IV, p. 135.

Dye. The generic name given to coloring matters in transparent mediums; suitable therefore for coloring fabrics or staining surfaces without providing a protective covering such as is given by paints proper. The distinction between dyes and paints is, however, not always very clearly adhered to. See "Paints, Dyes, and Varnishes," Vol. VIII, p. 314.

Dynamics. The science that deals with the motions of bodies, and with the forces that actuate these motions; in contradistinction to "statics," which deals with stationary bodies.

Dynamo. The apparatus, consisting essentially of a coil of wire conveying a current of electricity and made to revolve in a magnetic field, which transforms molar energy (usually supplied by a steam engine or by a water-wheel) into electrical energy. The multitudinous practical applications of electricity to the supplying and transmitting of power (trolleys, elevators, etc.) are dependent upon the dynamo, the perfecting of which took place late in the nineteenth century. See "Man's Newest Co-laborer: The Dynamo," Vol. VI, p. 171. For Faraday's experiments leading up to the development of the dynamo, see "Faraday and Electro-magnetic Induction," Vol. III, p. 240.

Dynamo-electric Machines. Name originally applied to all machines intended to perform work with the aid of electricity, subsequently contracted to "dynamo."

TECHNICAL INDEX AND GLOSSARY

Electric Light. The light engendered by rendering a badly-conducting material incandescent by passing a current of electricity through it. The possibility of producing light in this way was discovered by Davy early in the nineteenth century; but no commercial use was made of the discovery till the middle of the century; and the first important commercial light (the Jablochkoff "candle") was not invented till 1876. Brush's arc light followed; and Edison's incandescent light is still more recent. See "The Banishment of Night," Vol. VI, p. 218.

Electricity. A familiar but inscrutable manifestation of energy, having for its unit structure, according to the most recent theory (J. J. Thomson), an infinitesimal corpuscle, or electron. Frictional electricity (e.g., due to rubbing amber) was known to the ancients; galvanic electricity was discovered by Galvani and Volta; dynamic electricity has been placed at the service of man in our own generation. For the earliest experiments in electricity, see "William Gilbert and the Study of Magnetism," Vol. II, p. 111; also, "Progress in Electricity from Gilbert and Von Guericke to Franklin," Vol. II, p. 259; "The Modern Development of Electricity and Magnetism," Vol. III, p. 229; "Prof. J. J. Thomson and the Nature of Electricity," Vol. V, p. 92. For such subjects as "The Electric Telegraph," "Electric Railways," "Electric Lighting," the reader is referred to chapters under these headings in this index and the general index.

Electric Railways. Electricity as a traction power owes its popularity simply to the fact that it can be transmitted conveniently to a distance over a wire (trolley) or third rail, or (less importantly) in a so-called storage battery. The initial experiments in this line were made as early as 1835 (Thomas Davenport); a little later (1847-1857), Thomas Hall, Dr. Colton, and Prof. C. C. Page continued the work, followed by a host of others. Galvanic cells and storage batteries were first used with some success, but the dynamo presently superseded other generators, although the storage battery, as perfected by Edison, again entered the field prominently in 1910. See "The Development of Electric Railways," Vol. VII, p. 175.

Electro-chemistry. An important branch of practical chemistry, that finds application in a multitude of commercial industries. The activities involved are chiefly either (1) the principle of electrolysis, whereby chemicals are dissociated (as, for

KEY AND INDEX

example, in copper-plating, silver-plating, etc.) in solution; or (2) the agency of high temperatures, as developed in the electric furnace, whereby substances are decomposed and purified or allowed to reunite in new compounds. See "Humphry Davy and Electro-chemistry," Vol. IV, p. 46. The use of electro-chemistry is the development of the first telegraphs. See "Galvanism Gives a New Stimulus to Inventors," Vol. VIII, p. 11. In connection with the reproduction of illustrations, see "The Introduction of Process Work," Vol. VIII, p. 202.

Electrolysis. The dissociation or decomposing of substances in solution through the passage of electric currents. In a solution of silver salts, for example, the silver (being "electro-positive") passes to the negative pole (cathode) and is there deposited. This is the action in the practical process of electro-plating. Similarly, solutions of copper compounds are used to plate surfaces with copper, as in making the plates from which books, half-tone pictures, etc., are printed. See "The Introduction of Process Work," Vol. VIII, p. 202. Cavendish's decomposition of the water atom by the use of electricity, Vol. IV, p. 14. See also "Electro-chemistry" of this index.

Electro-magnetism. A manifestation of energy due to the curious relations that exist between magnetism and electricity, whereby, under certain circumstances, one may be induced by the other. See "Faraday and Electro-magnetic Induction," Vol. III, p. 240. See also in the present index, "Dynamo," "Electricity," "Electron," "Hertzian Waves."

Electron. The hypothetical unit structure of electricity, the theory of which has been chiefly developed by Prof. J. J. Thomson. The negative electron is believed to have about one one-thousandth the mass of the hydrogen atom. It may be the basis of all matter. Professor Thomson made tentative announcement of the probable discovery of the positive electron in 1910. See "Professor J. J. Thomson and the Nature of Electricity," Vol. V, p. 92.

Electro-plating. See Electrolysis.

Element. The final chemical analysis, so far as at present achieved, resolves all known forms of matter into seventy-odd so-called elements, each having an atomic structure, which resists further dissociation, and which presents definite and characteristic properties of size and chemical valency. Their names and atomic weights are:

TECHNICAL INDEX AND GLOSSARY

Aluminum	Al	27.1	Molybdenum	Mo	96.
Antimony	Sb	120.2	Neodymium	Nd	143.6
Argon	A	39.9	Neon	Ne	20.
Arsenic	As	75.	Nickel	Ni	58.7
Bromine	Br	79.96	Niobium	Nb	94.
Barium	Ba	137.4	Nitrogen	N	14.04
Beryllium	Be	9.1	Osmium	Os	191.
Bidymium	Di	142.	Oxygen	O	16.
Bismuth	Bi	208.5	Palladium	Pd	106.5
Boron	B	11.	Phosphorus	P	31.
Cadmium	Cd	112.4	Platinum	Pt	194.8
Caesium	Cs	133.	Potassium	K	39.15
Calcium	Ca	40.1	Praseodymium	Pr	140.5
Carbon	C	12.	Radium	Ra	225.
Cerium	Ce	140.	Rhodium	Rh	103.
Chlorine	Cl	35.45	Rubidium	Rb	85.4
Chromium	Cr	52.1	Ruthenium	Ru	101.7
Cobalt	Co	59.	Samarium	Sm	150.
Columbium	Cb	93.5	Scandium	Sc	44.1
Copper	Cu	63.6	Selenium	Se	79.2
Dysprosium	Dy	162.5	Silicon	Si	28.4
Erbium	Er	166.	Silver	Ag	107.93
Europium	Eu	152.	Sodium	Na	23.05
Fluorine	F	19.	Strontium	Sr	87.62
Gadolinium	Gd	156.	Sulphur	S	32.06
Gallium	Ga	70.	Tantalum	Ta	183.
Germanium	Ge	72.5	Tellurium	Te	127.6
Gold	Au	197.2	Terbium	Tb	160.
Helium	He	4.	Thallium	Tl	204.1
Hydrogen	H	1.008	Thorium	Th	232.5
Indium	In	114.	Thulium	Ta	171.
Iodine	I	126.85	Tin	Sn	119.
Iridium	Ir	193.	Titanium	Ti	48.1
Iron	Fe	55.9	Tungsten	W	184.
Krypton	Kr	87.8	Uranium	U	238.5
Lanthanum	La	138.9	Vanadium	V	51.2
Lead	Pb	206.9	Xenon	X	128.
Lithium	Li	7.03	Ytterbium	Yb	173.
Lutecium	Lu	174.	(Neoytterbium)		
Magnesium	Mg	24.36	Yttrium	Y	89.
Manganese	Mn	55.	Zinc	Zn	65.4
Mercury	Hg	200.	Zirconium	Zr	90.6

KEY AND INDEX

Elevator. The contrivance (in England called a "lift") for conveying passengers and freight to the upper stories of buildings, through which the modern skyscraper has been made tenatable. The earlier forms were operated by a piston-rod resting on a water cushion, but for very high buildings the electric elevator has practical monopoly. See "Elevator or 'Lift,'" Vol. IX, p. 169.

Embryology. The science that deals with the development of the embryo while in the egg or womb. The study is highly important in its bearing on physiological and evolutionary problems. See "The Cell Theory Elaborated," Vol. IV, p. 122, for the studies of Schwann, von Baer, Müller, and Carpenter.

Energy. The capacity to do work. Energy may be potential, as represented by a stone held in the hand; or kinetic (operative), as when the stone is dropped. Various manifestations of energy (as molar motion, molecular activity, heat, electricity) may be transmuted one into another; but energy can be neither created nor destroyed (doctrine of the conservation of energy; see Mayer, Joule, Helmholtz). There is, however, a seeming loss of energy from the solar system, through the constant sending out of radiant heat. See "The Conservation of Energy," Vol. III, p. 253; "Lord Kelvin and the Dissipation of Energy," Vol. III, p. 274; "How Work is Done," Vol. VI, p. 29.

Engines. See Atmospheric e., Electric e., Gas e., Hot-air e., Piston e., Steam e., and Water e., and "Captive Molecules: The Story of the Steam Engine," Vol. VI, p. 79; "The Master Worker," Vol. VI, p. 110; "Gas and Oil Engines," Vol. VI, p. 133.

Epicycles, Theory of. A theory invented or elaborated by Hipparchus (second century B.C.) to explain the observed fact that the sun spends more time on one side of the equator than on the other, and that the moon and planets show similar irregularities of action. The theory supposes that the circling bodies describe minor circles about invisible centers. These fictitious epicycles continued to be evoked by astronomers until Kepler discovered that the true explanation of the observed anomalies is, not that the bodies describe minor circles (epicycles), but that their orbit is elliptical. The theory of epicycles was thus shown to be utterly untenable; yet it had seemed to offer a valid explanation of observed phenomena. See "Hipparchus, 'The Lover of Truth,'" Vol. I, p. 233; "The New Cosmology," Vol. II, p. 74.

TECHNICAL INDEX AND GLOSSARY

Etching. A process of engraving, in which the artist scratches the waxed surface of the metallic plate with a pointed instrument, the mechanical process being completed by the action of acids, which "bite" the plate only in places thus exposed. See "Etching," Vol. VIII, p. 195.

Ether. The hypothetical substance filling all space, "penetrating between the molecules of matter as air between the leaves of trees." One theory of matter supposes all material substances to be composed of vortex rings of ether. Undulations in the ethereal medium are supposed to constitute the manifestations which our senses interpret as light and radiant heat. For the investigation of the early workers, such as Young and Clerk-Maxwell, to the most recent, see "The Ether and Ponderable Matter," Vol. III, p. 283.

Evolution, The Theory of Organic. The doctrine which teaches that higher organic forms have developed sequentially from lower ones, through various channels, all of which lead back to a primordial form of proto-plasmic being. See Darwin, Erasmus Darwin, Lamarck, Haeckel, and "Theories of Organic Evolution," Vol. IV, p. 140.

Faraday Tubes. Lines of magnetic force, as observed by Faraday, and theoretically explained by him. These "tubes" radiate in all directions into space, in loops of all sizes, which connect the poles of a magnet. They have been invoked to explain many phenomena of nature, including "action at a distance." See "Modern Views," Vol. VI, p. 153.

Fire-damp. Name given by miners to the explosive or inflammable gases that sometimes develop in mines, in contradistinction to the non-explosive carbonic acid gas, which they term "choke damp." See "Carbon Dioxide Gas," of the present index.

Fossil Beds. Strata containing large numbers of fossils; usually from remains originally deposited in an ancient lake bed. Some of the most important fossil beds are found in the Rocky Mountain region. See "The New Science of Paleontology," Vol. III, p. 74.

Fossil Horse. Remains of this animal, as found in the fossil beds of western America, had peculiar interest, as they gave tangible evidence of the truth of the evolution of hypothesis. See "The New Science of Paleontology," Vol. III, p. 105.

Fossil Man. Remains of prehistoric man, study of which has demonstrated the great antiquity of the human race. Finds of

KEY AND INDEX

this character are always of interest, but are no longer startling as they were at the middle of the nineteenth century, when the "age of man" was supposed to compass a mere six thousand years. See "The New Science of Paleontology," Vol. III, p. 98.

Friction. The motion-retarding influence exerted by one surface against another, or by a gas or liquid acting on another gas or liquid or on a solid. Friction is responsible for enormous loss of power in the operation of all working mechanisms; but, on the other hand, were it not for friction man would not be able to handle tools, or even to walk. See "Other Means of Transmitting Power," Vol. VI, p. 35.

Ganglion Cells. Central nerve cells, located in the brain, the spinal cord, or in the outlying plexuses, which serve as store-houses of nervous energy. See "Functions of the Nerves," Vol. IV, p. 259.

Gas. Matter in the state of tenuousness in which its component molecules, instead of being relatively close together and more or less subject to the influence of cohesive forces (solids, liquids), are widely separated, and in rapid linear motion, darting hither and thither, and rebounding on contact. (See Maxwell; Kinetic theory.) All kinds of matter assume the gaseous state under proper conditions of pressure and temperature. Substances that are gaseous at ordinary terrestrial temperatures are spoken of as "permanent gases," but the term is a misnomer. For Clerk-Maxwell's kinetic theory of gases, see Vol. III, p. 295. For the "Law of Avogadro," see Vol. IV, p. 57. For recent experiments in liquifying gases, see Vol. V, p. 53. For some recent discoveries of new gases, see Vol. V, p. 84.

Gas Engine. An engine actuated by some gas other than steam. Gas engines are of recent development; the best-known form being the explosion engine generally used for automobiles and motor boats. See "Gas and Oil Engines," Vol. VI, p. 132.

Gas Mantle. A mantle, of which that of Herr Welsbach is the type, composed of an earth (e.g., a compound of thorium and cerium) which becomes incandescent when heated in a gas flame; giving far more light than would be produced by the gas flame itself. See "The Incandescent Gas Mantle," Vol. VI, p. 208.

Gastric Juice. The digestive juice secreted by the stomach. It is acidulous (hydrochloric acid) and its most characteristic and important constituent is the ferment pepsin. See "The Chemical Theory of Digestion," Vol. IV, p. 88.

TECHNICAL INDEX AND GLOSSARY

Gears. Mechanisms for transmitting power, or for changing the direction of its action. The toothed wheel and the bitted wheel are typical examples. See "Other Means of Transmitting Power," Vol. VI, p. 35.

Gems. Minerals, usually in crystalline form, the combined beauty and rarity of which gives them great commercial value, usually quite without regard to any question of practical utility. The diamond (a crystal of pure carbon) owes its popularity to its hardness, combined with its high index of refraction; the true ruby, sapphire, and emerald are crystallized oxides of aluminum (corundum) with traces of different coloring matters. Stones of the corundum order are now duplicated in the laboratory on a commercial scale; but laboratory diamonds are as yet of infinitesimal size. See "Gems, Natural and Artificial," Vol. IX, p. 295.

Geocentric Theory. The theory according to which the earth is the center of the solar system. This theory has universal vogue (notwithstanding the protest of Aristarchus) throughout antiquity; the true heliocentric theory was put forward by Copernicus. See "Aristarchus of Samos, the Copernicus of Antiquity," Vol. I, p. 212.

Geology. The science that deals with the origin, structure, and metamorphoses of the earth's crust. It is, in any comprehensive sense, a modern science, its correct theories dating from the close of the eighteenth century. See "The Origin and Development of Modern Geology," Vol. III, p. 116.

Geometry. Literally, and in its earliest applications, the science of earth measurement. As such its elements were understood by the ancient Egyptians. Expanded and its chief propositions formulated by the Alexandrian, Euclid (300 B.C), whose exposition is still used in modern text-books. See "Euclid," Vol. I, p. 192.

Germanium. See "Elements" in the present index.

Glands. Secretory organs, of which there are many types, as, for example, the salivary glands, the peptic glands of the stomach, the pancreatic glands, and sundry intestinal glands. See also "Ductless Glands" of the present index.

Glass. A crystalline substance, the chief constituent of which is silica (sand), with which varying proportions of potash, soda, and lime are combined. See "Glass and Glass-Making," Vol. IX, p. 277.

Glass Negatives. See "Photography" in the present index.

KEY AND INDEX

Goniometer. An implement for measuring solid angles, or the inclination of planes, particularly the angles formed by the faces of crystals.

Gravitation. The universal force of attraction acting between all masses of matter in the universe; in virtue of which, as demonstrated by Newton, the power of attraction between any two bodies is directly as their combined mass and inversely as the square of their distance. The nature of gravitation remains a mystery despite various attempts to explain it. See "Newton and the Law of Gravitation," Vol. II, p. 236. For Le Sage's theory of, see "Physical Problems," Vol. V, p. 213.

Gyrocar. Name given to Mr. Brennan's monorail vehicle, which owes its stability to the action of gyroscopic wheels. See "The Gyrocar," Vol. VII, p. 195.

Gyroscope. A revolving body; for example, a top, a hoop, or the earth itself. More technically, a wheel adjusted in gimbal frames to illustrate the principles of gyroscopic action; in particular, the stability acquired by a rapidly revolving body. See "Gyrocar," Vol. VII, p. 195, and "The Gyroscope and Ocean Travel," Vol. VII, p. 217.

Gyroscopic Action. See "Gyroscope" in the present index.

Heat. A manifestation of energy believed to represent active molecular vibration. These vibrations may set up undulations in the ether, which are interpreted as radiant heat; these undulations can in turn transmit motion (i.e., "heat") to the molecules of matter upon which they infringe—as we see illustrated when anything is warmed by the sun's rays. Heat was long supposed to be an "imponderable" fluid. The true theory of heat was developed by Count Rumford, Carnot, Mayer, Joule, and Helmholtz. See "Modern Theories of Heat and Light," Vol. III, p. 206.

Heliocentric Theory. The true theory that the sun is the central body of the planetary system was advocated in antiquity by Aristarchus; but did not gain currency until put forward by Copernicus in the fifteenth century. See "The New Cosmology—Copernicus to Kepler and Galileo," Vol. II, p. 52.

Hertzian Waves. The electro-magnetic waves in the ether that are utilized in wireless telegraphy. Named for Hertz, whose studies first clearly demonstrated the characteristics of these high-frequency ethereal waves. See Vol. III, p. 247; also "Wireless Telegraphy," Vol. VIII, p. 47, and "The Wireless Telephone," Vol. VIII, p. 88.

TECHNICAL INDEX AND GLOSSARY

Histology. The science that deals with the minute structure of animal and vegetable tissues. This science depends very largely upon the microscope, and has developed chiefly since that instrument was perfected. See "Lister and the Perfected Microscope," Vol. IV, p. 109.

Horse Power. The unit of work, as applied by Watt to the steam engine. Watt assumed that a horse could perform an amount of labor equivalent to the raising of 33,000 pounds to the height of one foot in one minute; this was doubtless an over-estimate, but it has remained the standard. See Vol. VI, p. 60.

Hot-air Engine. An engine in which heated air is used instead of steam or exploded gas to propel the piston. See "Gas and Oil Engines," Vol. VI, p. 132.

Hydrophobia. See "Rabies" in the present index.

Hydrostatic Press. An apparatus for transmitting power; it makes use of the principle that pressure applied to a given surface of a liquid is transmitted unmodified to each corresponding surface of the enclosing well. In practice a small force applied to a small piston in a cylinder becomes multiplied as transmitted to the large piston of a connecting cylinder. See "Hydraulic Power," Vol. VI, p. 74.

Hydrostatics. The science that deals with the properties of fluids. For Archimedes's solution of some of the most important problems of hydrostatic equilibrium, see Vol. I, p. 196. For the experiments of Galileo, see "Galileo and the Equilibrium of Fluids," Vol. II, p. 105.

Hygiene. The science of health; in particular having to do with improvements in living, ventilation, sanitation, etc. See "The Berlin Institute of Hygiene," Vol. V, p. 193.

Hypnotism. Name given by Dr. Braid to the practice of inducing artificial somnambulism in a susceptible subject. The hypnotic condition is subjective, and is indeed by suggestion, not by the giving out of any "magnetic" or other occult influence on the part of the hypnotist. See "Physiological Psychology," Vol. IV, p. 266.

Inclined Plane. A familiar mechanism through the use of which heavy bodies may be raised to a height with a conservative use of power. Diodorus Siculus records that the Egyptian utilized the principle of the inclined plane in building the pyramids. See "Inclined Planes and Derricks," Vol. VI, p. 37.

Induction, Electric. A curious phenomenon, in which an elec-

KEY AND INDEX

tric current is generated in a coil of insulated wire wound about another coil, through which a current generated in the usual way is passed. The familiar Faradic current is thus induced. For a description of the discovery of induction, see "Progress in Electricity from Gilbert and Von Guericke to Franklin," Vol. II, p. 259. For Faraday's experiments, see Vol. III, p. 240.

Inorganic Matter. Mineral compounds of whatever character that have been developed or compounded without the aid or interposition of living organisms, vegetable or animal.

Interference of Light. The collision of one wave of light (etherial undulation) with another in such a way as to obstruct the wave, causing darkness. Studies of interference led Young to the elaboration of the undulatory theory of light. See "Thomas Young and the Wave Theory of Light," Vol. III, p. 215.

Isomerism. A word coined by the chemist Berzelius to indicate the fact, demonstrated in 1823 by Liebig and Wohlen, that two substances exhibiting different physical properties may have precisely the same chemical composition. See "Organic Chemistry and the Idea of the Molecule," Vol. IV, p. 53.

Julian Calendar. The reformed calendar of Julius Cæsar, which adopted the Alexandrian expedient of introducing an additional day every fourth (leap) year. For comparison of this calendar and with that of the ancient Egyptian calendar, see "Astronomical Science," Vol. I, p. 33.

Kinematograph. See Chrono-photography, Vol. VIII, p. 248.

Kinetic Theory (of gases). The theory that a gas consists of molecules in a state of agitation, describing a "free path" of relatively great length between successive impacts with other molecules. See Vol. III, p. 295.

Knitting Machinery. A machine for knitting stockings was invented by a Scottish clergyman, William Lee, in 1589; a development that permitted the knitting of a ribbed surface was introduced by Jedediah Strutt in 1758; and the circular knitter (producing a seamless stocking) was perfected by Peter Claussen in 1845. See "Lace Making and Knitting Machinery," Vol. IX, p. 55.

Krupp Steel. An alloy steel, containing nickel, which adds to its hardness and gives it great value for armoring ships. See "The Age of Steel," Vol. VI, p. 295.

TECHNICAL INDEX AND GLOSSARY

Lamp, Safety. A lamp invented by Humphry Davy, for use in mines, to give protection against danger from explosion due to "fire-damp." The device consists essentially of enclosing the lamp in wire gauze. See "Conditions to be Considered in Mining," Vol. VI, p. 247.

Latent Heat. A term introduced by Dr. Joseph Black to apply to the modicum of heat which seemingly disappears or becomes latent when a substance changes its physical state, as, for example, when water is transformed into steam. The heat reappears when the steam is retransformed into water. Black's studies in this field were probably a source of inspiration to his friend Watt, in connection with the perfecting of the steam engine. See Vol. VI, p. 94.

Latitude. Distance north or south from the equator, measured in degrees, minutes and seconds of arc. Latitude is determined with comparative ease by the mariner through observation of the height of the sun at meridian, as measured with the sextant. See "The Development of the Sextant," Vol. VII, p. 18.

Law, Natural. The expression of an observed sequence of phenomena in nature, so often repeated that we are justified in regarding the sequence as inevitable.

Lever. An instrument which, in various modified forms, is the most universally employed of all instruments with which work is performed. The principles of the lever were formulated by Archimedes. See "How Work is Done," Vol. VI, p. 29.

Leyden Jar. Name given a simple apparatus for storing electricity generated by a friction machine, as discovered independently by Dean Von Kleist and Pieter von Musschenbrock in 1745. The original apparatus of Von Kleist consisted simply of a nail or a piece of brass wire placed in a glass bottle. See "The Leyden Jar Discovered," Vol. II, p. 280.

Light. The phenomena interpreted by the eyes as light and color consists essentially of undulations in the ether, having clearly defined upper and lower limits of frequency. This explanation of light was demonstrated by Young and Fresnel; and their theory supplanted the corpuscular or emanation theory that had been championed by Newton. The undulations in the ether that are interpreted as light are induced by vibrations of molecules of matter ordinarily produced by excessive heat; in other words, light is a manifestation of energy. See "Modern Theories of Heat and Light," Vol. III, p. 206.

Lightning. A manifestation of atmospheric electricity, as was

KEY AND INDEX

first demonstrated by Benjamin Franklin's classical experiments with kite and key, made about the middle of the eighteenth century. See "Benjamin Franklin," Vol. II, p. 286.

Lime-light. A light produced by heating a block of lime to incandescence with a blast of oxygen or gas.

Liquefaction of Gases. Reducing gases, such as oxygen, hydrogen, air, etc., to a liquid state. See "Low Temperature Researches," Vol. V, p. 29.

Liquefied Air. See "Liquefaction of Gases" of the present index.

Liquid Fuel. The term given to the various oils, usually crude petroleum, which have come into use recently as fuel for locomotives, steamships, etc. See "Liquid Fuel," Vol. VII, p. 90.

Lithography. The process of reproducing pictures from an etched surface of stone. The process was invented by Alois Sanfelder early in the nineteenth century. See "The Reproduction of Illustrations," Vol. VIII, p. 184.

Locomotive. The traction vehicle perfected, but not invented, by George Stephenson. The earliest locomotives were those of Cugnot and Trevithick. Locomotives were used in collieries for a good many years before Stephenson made his memorable demonstration with the Rocket in 1829. See "The Steam Locomotive," Vol. VII, p. 119.

Log. An apparatus for measuring the speed of ships. Originally this consisted of a log or block of wood attached to a knotted rope. This log was dropped into the water astern, and the speed of the ship was estimated from the number of knots that ran through the fingers while a half-minute sand-glass was emptying. The modern log revolves in the water, and records speed on a clock-like dial. See "Sailing by Dead Reckoning," Vol. VII, p. 14.

Longitude. Distance east or west of an arbitrarily selected meridian (as that of Greenwich, or that of Washington), as measured in degrees, minutes, and seconds of arc. The mariner determines his longitude by means of observation of sun or stars, in connection with the time record furnished by chronometer. See "The Development of the Sextant," Vol. VII, p. 18.

Loom. An apparatus for weaving cloth. The primitive hand loom had been used from remotest antiquity. The power loom was the invention of the British clergyman, Dr. Edmund Cartwright (1784). See "The Manufacture of Textiles," Vol. IX, p. 43.

TECHNICAL INDEX AND GLOSSARY

Low Temperature Researches. The work of Rumford, Davy, and Young, and later by Sir James Dewar and his associates in reducing gases, even hydrogen itself, to a liquid state, is described in "The Royal Institution and the Low Temperature Researches," Vol. V, p. 29.

Magdeburg Hemispheres. The name given two hollow brass hemispheres with tightly-fitting surfaces which, when approximated, and after the air had been exhausted, could not be pulled apart by teams of horses. With these Otto von Guericke, in the seventeenth century, demonstrated atmospheric pressure. See Vol. II, p. 211; Vol. VI, p. 66.

Magnet. A body which possesses the property of attracting fragments of iron or steel. The loadstone is a natural magnet. It is the native magnetic oxide of iron, Fe_3O_4 . See "Electricity," and "Electro-magnetism" of the present index.

Magnetism. The property possessed by certain bodies whereby they naturally attract or repel one another. See "Faraday and Electro-magnetic Induction," Vol. III, p. 240. Also "Electricity," and "Electro-magnetism" of the present index.

Magnetized Needle. A magnet in the form of a needle suspended at its center of gravity, which places itself naturally in a position with its long axis nearly north and south, with one end inclining downward. See "Electricity and Magnetism," Vol. III, p. 236. Also "The Mariner's Compass," Vol. VII, p. 7.

Mammalia (mammiferous animals, mammals). All those animals which suckle their young, and no others. Thus, whales, although fish-like in habits, are mammals quite as much as horses or cattle. For studies of fossil mammals, see "The New Science of Paleontology," Vol. III, p. 74; and "The Origin and Development of Modern Geology," Vol. III, p. 116.

Mantle, Gas. A porous, hollow cone, or bag-shaped structure, composed of the oxides of thoria, alumina, magnesia, etc., which when placed so that a mixture of air and illuminating gas passes through it, and is ignited, becomes brilliantly luminous. See "Gas Lighting," Vol. VI, p. 207.

Mariner's Compass. An instrument, apparently invented and used by the Chinese before the Christian era, in which a magnetized needle suspended at its center of gravity above a disk, is used for determining directions at sea. The short-needle compass, now used universally, was invented by Lord Kelvin about 1875. See "The Mariner's Compass," Vol. VII. p. 7.

KEY AND INDEX

Marine Galvanometer. An instrument consisting of a tiny magnet and a reflector with which telegraphic messages are magnified by reflected light. With this instrument, the invention of Lord Kelvin, very weak currents of electricity can be utilized for signaling. See "Instrumental Aids," Vol. VIII, p. 45.

Medicine. For the story of the development of the science of medicine, from the earliest time until the present, see "Scientific Knowledge of the Egyptian Physician," Vol. I, p. 49; "Babylonian Medicine," Vol. I, p. 75; "Empedocles, Physician, Observer, and Dreamer," Vol. I, p. 132; "Hippocrates and Greek Medicine," Vol. I, p. 170; "Galen, the Last Great Alexandrian," Vol. I, p. 278; "Arabian Medicine," Vol. II, p. 21; "Byzantine, and Thirteenth Century Medicine," Vol. II, p. 31; "From Paracelsus to Harvey," Vol. II, p. 156; "Medicine in the Sixteenth and Seventeenth Centuries," Vol. II, p. 181; "Eighteenth Century Medicine," Vol. IV, p. 182; "Nineteenth Century Medicine," Vol. IV, p. 200. Also see chapters on Anatomy and Physiology of the eighteenth and nineteenth centuries.

Mercury-vapor Light. An electric light, invented by Mr. Peter Cooper Hewitt, in which mercury vapor enclosed in a glass tube is made incandescent by the passage of an electric current. This type of lamp produces eight times as much light as the ordinary carbon filament lamp with the same amount of power. See "The Mercury-vapor Light of Peter Cooper Hewitt," Vol. VI, p. 236.

Meteorites, or Shooting Stars. Mineral or metallic masses, of extraterrestrial origin, which fall upon the earth, or are consumed while passing through the atmosphere toward the earth. See "The New Science of Meteorology," Vol. III, p. 168.

Meteorology. The science which treats of the motions and phenomena of the earth's atmosphere, the study of climate and weather, their causes, changes, and effects. See "The New Science of Meteorology," Vol. III, p. 168.

Mezzotint. A method of engraving on copper or steel, the surface of which has been uniformly roughened by an instrument called a "cradle" or "rocker." For dark tones the surface is left undisturbed, the lighter effects being produced by scraping away the surface. See "Mezzotint," Vol. VIII, p. 196.

Micrometer. An instrument, used in connection with the microscope, for measuring lengths and angles.

Microscope. An optical instrument for magnifying minute objects. Invented in 1590 by the Dutch optician Jensen. Im-

TECHNICAL INDEX AND GLOSSARY

proved by Robert Hooks, and finally brought to its present state of perfection by the efforts of Sir David Brewster, Dr. Wollaston, Coddington, and Joseph Jackson Lister. See "Lister and the Perfected Microscope," Vol. IV, p. 109.

Milky Way. A luminous band in the heavens, composed of stars and nebulae. This fact was discovered by Galileo with the telescope which he invented. See Vol. II, p. 79; and the general treatment of modern astronomy, "The Progress of Modern Astronomy," Vol. III, p. 19.

Molecule. The smallest mass of any substance that can exist in a separate form. The atom is, of course, smaller, but single atoms cannot exist alone. See "The Ether and Ponderable Matter," Vol. III, p. 283.

Monorail Systems. Railways having a single rail, on which cars with double-flanged wheels are kept in a state of equilibrium either by overhead supports, or by means of a gyroscope. The Gyrocar (q.v.) of Louis Brennan is an example of this latter type. See "The Gyrocar," Vol. VII, p. 195; and "Monorail Systems," Vol. VII, p. 191.

Moon's Variation, which was discovered by an Arabian astronomer about 975, is the inequality of motion of the moon, in virtue of which it moves quickest when new or full, and slowest at first and third quarter. Later (about 1750) this fact was re-discovered by Tycho Brahe. For modern studies of the moon, see "Studies of the Moon," Vol. III, p. 48.

"Mule." A spinning machine invented by Samuel Crompton about 1779. As it was a combination of the spinning-jenny and Arkwright's drawing-rollers—a hybrid machine—it was dubbed "mule," after that hybrid animal. See "The Invention of the 'Mule,'" Vol. IX, p. 32.

Multiple Messages. In telegraphy it is possible to send several messages at the same time in opposite directions over a single wire. The first machine for doing this was invented by an Austrian, Dr. Gintl, in 1853. See "Multiple Messages," Vol. VIII, p. 25.

Muscles. A kind of animal tissue capable of contracting in length and dilating in breadth. The voluntary muscles, as the biceps of the arm, are under control of the will, while the involuntary muscles, such as those of the heart, intestines, etc., are not. All muscles respond to electrical stimuli. See "The Animal Machine," Vol. VI, p. 43.

KEY AND INDEX

Muscular System. The term applied to all muscles of the body as distinguished from the nervous system, osseous system, etc.

Nautical Almanac. An almanac published by the United States and other maritime powers, for the use of astronomers and navigators, in which is given the angular distances of the moon from the sun, planets, and fixed stars, etc., and other information that enables the navigator to determine exact positions of latitude and longitude. See "The Conquest of the Zones," Vol. VII, p. 37.

Neolithic Civilization. A term applied especially to the civilization of northwestern Europe during the epoch of highly finished and polished stone implements. It was the later period of the "stone age," the earlier period being the Paleolithic age.

Neon. A gaseous element discovered in the earth's atmosphere by Ramsay and Travers in 1898. See "Some Physical Laboratories and Physical Problems," Vol. V, p. 84.

Neptune. (1) In Roman mythology the god of the sea; (2) in astronomy the most distant of the known planets. It is peculiar in revolving from east to west, and revolves around the sun in 164.6 years. See "The Discovery of Neptune," Vol. III, p. 42.

Neptunists. The name given to the followers of Werner of Saxony, who believed that "in the beginning all the solids of the earth's crust were dissolved in the heated waters of a universal sea." The opponents of this theory, who followed James Hutton's teachings, were called "Plutonists." See "Neptunists versus Plutonists," Vol. III, p. 131.

Nerve Cells. Structures in the brain from which the nerve-filaments originate. They may be likened to "a central telephone office of a telephone system." See "The New Science of Experimental Psychology," Vol. IV, p. 249.

Nerves. Filaments leading from the nerve cells of the brain to various structures of the body, such as muscles, glands, etc., which serve as conductors of impulses, to and from the brain. Sir Charles Bell, in 1811, discovered that there are two distinct sets of nerves, one for carrying motor and the other for carrying sensory impulses. See "Experimental Psychology," Vol. IV, p. 249.

Nitrate Beds. Large areas in northern Chili, Peru, and Bolivia, containing sodium nitrate (NaNO_3) in a native state. This substance is valuable as a fertilizer, and as a source of

TECHNICAL INDEX AND GLOSSARY

nitric acid and of nitre. See "Nitrogen from the Air," Vol. VI, p. 303.

Nitrogen. A gaseous, non-metallic element, constituting 77 per cent by weight, or four-fifths by bulk, of the earth's atmosphere. Discovered by Henry Cavendish about 1809. See "Henry Cavendish," Vol. IV, p. 13; and "Nitrogen from the Air," Vol. VI, p. 303.

Nuclei of Plant Cells. The component part of the vegetable cell, first recognized by Robert Brown in 1833. See "Robert Brown and the Cell Nucleus," Vol. IV, p. 115.

Oil Engines. See "Gas and Oil Engines," Vol. VI, p. 132.

Organic Evolution. The changes in living organisms, the outgrowth of which is their present forms. See "Theories of Organic Evolution," Vol. IV, p. 140.

Organic Matter. The term applied to animal and vegetable matter as distinguishing it from mineral, or inorganic, matter.

Organicists' System. A system of medicine in vogue during the eighteenth century, the followers of which did not believe that life was due to some spiritual entity, but rather to the structure of the body itself. See "Animists, Vitalists, and Organicists," Vol. IV, p. 184.

Oxygen. A non-metallic gaseous element, discovered in 1774 by Joseph Priestley, and called by him "dephlogisticated air." Later Lavoisier gave it the name oxygen (chemical symbol O). See "Joseph Priestley," Vol. IV, p. 18.

Paint. Colors or dyes mixed with some vehicle, such as oil, turpentine, water, etc., so as to spread over a surface and retain their brilliancy after drying. See "Paints, Dyes, and Varnishes," Vol. VIII, p. 258.

Paleontology. The science of ancient life that inhabited the earth during the ages previous to historic times. The science originated early in the nineteenth century and was named by de Blainville and Fischer von Waldheim in 1834. See "The New Science of Paleontology," Vol. III, p. 74.

Palladium. A metal resembling platinum, used in the manufacture of certain scientific instruments. It was discovered by Wollaston in 1803. See "Element" of the present index.

Paper. A material composed of vegetable fibers formed artificially into thin sheets. It came into use about the twelfth century in Europe, but was probably known and used long

TECHNICAL INDEX AND GLOSSARY

before that in the Orient. See "The Manufacture of Paper," Vol. VIII, p. 159.

Parasitic Diseases. Diseases caused by animal or vegetable parasites, such as the itch, caused by the burrowing under the skin of the itch mite, or the disease trichinosis, due to the presence of trichinæ burrowing in the tissues. See "Parasitic Diseases," Vol. IV, p. 204.

Pepsin. A ferment secreted by the mucous lining of the stomach, discovered by Schwann and Wasmann, 1836-1840. When combined with an acid solution it has the power of transforming coagulated albuminous substances into soluble peptones. See "Animal Chemistry," Vol. IV, p. 128.

Percussion. In medicine, the method of investigation which consists in striking the surface of the body to ascertain from the sounds produced the condition of the parts beneath. Introduced in modern times by Avenbrugger, and afterward adopted by Laënnec and Corvissart. See "Nineteenth Century Medicine," Vol. IV, p. 199.

Periodic Law. A term expressive of the observed fact that the chemical elements when listed serially in the numerical order of their atomic weights show a curious recurrence of similar properties at intervals of eight elements. See "Periodicity of Atomic Weights," Vol. IV, p. 64.

Periscope. An optical instrument used for making observations from a submarine boat when submerged. See "Submarine Vessels," Vol. VII, p. 93; in particular p. 111.

Phantoscope. A form of moving-picture machine. See "Chrono-photography—Moving Pictures," Vol. VIII, p. 248.

Phlogiston. A hypothetical substance, at one time supposed to be part of all bodies capable of being burned. The Phlogiston theory was developed by George Ernst Stahl (1660-1734), following the experiments of Becker (1635-1682). See "The Phlogiston Theory in Chemistry," Vol. IV, p. 3.

Phonautograph. An instrument invented by Leo Scott in 1856, with which vibrations made by sounds were recorded on smoked glass by means of a needle attached to a diaphragm. See "The Edison Phonograph," Vol. VIII, p. 93.

Phonograph. A device for recording and reproducing sounds, invented by Thomas A. Edison in 1877. See "The Edison Phonograph," Vol. VIII, p. 93.

Photography. The art of producing pictures by the action of light on chemically prepared surfaces. The first camera image

KEY AND INDEX

was produced by Niepce in 1827; but the honor of bringing photography to a practical stage of development belongs to Daguerre, dating from January, 1839. See "Photography in its Scientific Aspects," Vol. VIII, p. 220.

Photogravure. A process of engraving, done partly by photography, and by mechanical and chemical action on copper plates, from which prints can be made in a copper-plate press. See "The Reproduction of Illustrations," Vol. VIII, p. 184; in particular p. 217.

Phrenology. A doctrine, advanced by Dr. Franz Joseph Gall, which maintains that the external configurations of the skull are indicative of certain mental characteristics. See "The New Science of Experimental Psychology," Vol. IV, p. 247.

Physical Diagnosis. A method of external examination, introduced by Corvissart, the physician to Napoleon, whereby diseased conditions are detected by certain mechanical methods of examination, such as "chest-tapping," etc. See "Nineteenth Century Medicine," Vol. IV, p. 199.

Physics. The science that deals with matter and its properties and with the transformations of energy. From this it will be seen that its scope is very wide and far-reaching. See "Galileo and the New Physics," Vol. II, p. 93; "Modern Theories of Heat and Light," Vol. III, p. 206; "The Conservation of Energy," Vol. III, p. 253; "The Ether and Ponderable Matter," Vol. III, p. 283; "The Royal Institution and Low-temperature Researches," Vol. V, p. 29; "Some Physical Laboratories and Physical Problems," Vol. V, p. 73; "Some Unsolved Scientific Problems," Vol. V, p. 203. Electricity (q.v.) is a department of Physics, and nearly all the appliances of the mechanical world fall within the scope of Applied Physics. See, for example, the chapter "How Work is Done," Vol. VI, p. 29.

Physiology. In a restricted sense it is applied to that department of inquiry which investigates the functions of living organisms, such as the functions of the brain, liver, etc. In a broader sense it covers the sum of all knowledge concerning living organisms. See "Anatomy and Physiology in the Eighteenth Century," Vol. IV, p. 73; and "Anatomy and Physiology in the Nineteenth Century," Vol. IV, p. 102.

Pigments. The name given to paints, or any preparations used by painters and dyers. Also, the coloring matter found in the tissues of most animals and plants. See "Paints, Dyes, and Varnishes," Vol. VIII, p. 258.

TECHNICAL INDEX AND GLOSSARY

Piston Engine. A form of engine invented by Denis Papin about 1688. The name is still used to distinguish certain types of engines (such as the locomotive) from rotary engines, turbine engines, etc. See "Captive Molecules: The Story of the Steam Engine," Vol. VI, p. 79.

Pitch-blende. A heavy, black, pitchy-looking mineral, found principally in Saxony, Bohemia, Cornwall, and Colorado. It was while experimenting with this substance that M. Henri Becquerel discovered the so-called "Becquerel rays" in 1896. See "Radio-activity," Vol. V, p. 97.

Plagues. The name given to epidemics of various diseases which caused great loss of life during the middle ages and until quite recent times.

Polonium. An element discovered by Mme. Skoldowska Curie in 1898. Mme. Curie discovered it while examining the mineral pitch-blende (q.v.) and named it in honor of her native country, Poland. For chemical symbol and atomic weight, see "Element," in the present index.

Ponderable Matter. See "The Ether and Ponderable Matter," Vol. III, p. 283.

Power. In mechanics and physics, the application of energy through which work is performed; also, the rate at which work is performed—that is, the amount of work performed per unit of time. See "How Work is Done," Vol. VI, p. 29. The subject of power as generated by muscles, wind, water, steam, and electricity will be found in the chapters dealing especially with these subjects. See general index.

Predynastic Period. The period in Egyptian history antedating the historic period.

Printing. For the full account of the development of printing, see "The Printing and Making of Modern Books," Vol. VIII, p. 119. In the same volume are the chapters dealing with the closely allied subjects, "The Manufacture of Paper," p. 159; and "The Reproduction of Illustrations," p. 184.

Protoplasm. An albuminous elementary organic compound which enters into the composition of organized tissues of all kinds. See "The Cell Theory Elaborated," Vol. IV, p. 122.

Psychology. That branch of knowledge which deals with the mind. See "The New Science of Experimental Psychology," Vol. IV, p. 245.

Pulley. A wheel turning on a pin, having a groove on its circumference in which runs a rope for turning it. It is a form

KEY AND INDEX

of lever that was well known to the ancients, but Archimedes brought it to its highest state of perfection. See "Wheels and Pulleys," Vol. VI, p. 32.

Pump. A machine for raising liquids or extracting gases. The common form is the piston pump, but there are also centrifugal, rotary, electric pumps. For the invention of the air-pump, see "Mariotte and Von Guericke," Vol. II, p. 210. For the development of steam pumps, see "The Story of the Steam Engine," Vol. VI, p. 79. For pumps run by hot-air engines, see "Gas and Oil Engines," Vol. VI, p. 132. For electric pumps, see "Electric Mining Pumps," Vol. VI, p. 263.

Quadrant. An old form of sextant (q.v.).

Quinine. An alkaline substance obtained from the bark of trees of the cinchona genus. The bark of these trees was introduced as a medicine in 1640.

Rabies. A germ-produced disease affecting certain animals, especially dogs, from which hydrophobia is communicated. Pasteur discovered a preventive inoculation for this disease. See "Aims and Objects of the Pasteur Institute," Vol. V, p. 182.

Radio-activity. The property possessed by certain substances of spontaneously and continuously emitting penetrating rays capable of passing through bodies opaque to ordinary light. It was discovered by M. Henri Becquerel in 1896. See "Radio-activity," Vol. V, p. 97.

Radiolarians. Creatures of microscopic size found in the mud of the ocean bottom, etc. Prof. Ernst Hæckel discovered, named, and described more than 4,000 new species, obtained from a few ounces of mud. See "Ernst Hæckel and the New Zoology," Vol. V, p. 153.

Radium. A new element discovered by Professor and Mme. Curie in 1898, which possesses remarkable powers of radiation. See "Radio-activity," Vol. V, p. 97.

Refrigerator Machines. Mechanisms for producing very low temperatures, used for liquefying gases, such as hydrogen, air, etc. See "The Royal Institution and Low Temperature Researches," Vol. V, p. 38.

Respiration. The process of taking in oxygen and giving off carbon dioxide by the respiratory organs of animals. In man and the higher animals this function is performed by the lungs.

TECHNICAL INDEX AND GLOSSARY

This fact was not established until late in the eighteenth century. See "The Function of Respiration," Vol. IV, p. 92.

Rhodium. A metal belonging to the platinum group, discovered by Wollaston in 1804. See "Element" in the present index for chemical symbol and atomic weight.

Rosetta Stone. A slab of black rock found in Egypt, the inscriptions on which furnished the key for the decipherment of the Egyptian hieroglyphics. It was discovered in Egypt in 1799, and is now in the British Museum. See "The New Science of Oriental Archæology," Vol. IV, p. 287.

Rotary Engine. A type of engine in which rotary motion is obtained direct, without change of direction as in the case of reciprocating engines. The turbine engine is an example of a rotary steam engine. See "Rotary Engines," Vol. VI, p. 119.

Ruby. A precious stone, rich red in color, a transparent variety of corundum. It can be produced artificially of considerable size. See "Gems, Natural and Artificial," Vol. IX, p. 319.

Saliva. A liquid secreted by the salivary glands of the mouth, containing a digestive ferment. See "Animal Chemistry," Vol. IV, p. 128.

Sarcode. The name given by Dujardin to the viscid, slimy fluid, capable of motion, found within the cell wall. See "The Cell Theory Elaborated," Vol. IV, p. 122.

Scandium. One of three then unknown elements, the existence of which were predicted by Mendeleeff on formulating his periodic law. See "Periodicity of Atomic Weights," Vol. IV, p. 64.

Serum-therapy. A method of treating certain diseases by means of the modified blood serum of man or the lower animals. Behring's diphtheria antitoxine serum, discovered in 1892, is an example. See "Preventive Inoculation," Vol. IV, p. 231, and "Serum-therapy," Vol. IV, p. 240; also, "Aims and Objects of the Pasteur Institute," Vol. V, p. 182.

Sextant. A portable instrument for measuring the altitudes of heavenly bodies above the horizon, or their angular distance as seen in the sky; hence its use with the chronometer in determining exact latitude and longitude. See "The Development of the Sextant," Vol. VII, p. 18.

Shooting-stars. See Meteorites.

Signatures, Doctrine of. A mediæval theory, which in effect

KEY AND INDEX

was that every organ or part of the body had a corresponding form in nature, whose function was to heal diseases of the organ it resembled. See "Paracelsus," Vol. II, p. 156.

Siphon Recorder. An instrument for reading cable messages invented by Lord Kelvin in 1867, in the form of a tube of ink so arranged that as the message comes over the wire fine drops of ink are projected upon a piece of paper in lines whose deflections can be made to represent the Morse code. See "The Submarine Cable," Vol. VIII, p. 45.

Sliding Rule. An instrument, used in measuring surfaces and solids, etc., which consists of two graduated and numbered pieces of wood or other material, one of which slides in the groove of the other.

Solar and Telluric Problems. Problems pertaining to the solar system and to the earth. See "Some Unsolved Scientific Problems," Vol. V, p. 203.

Sothic Cycle. A period of the Egyptian calendar measured by the heliacal rising of Sothis. See "Astronomical Science" (Egyptian), Vol. I, p. 33.

Spark Recorder. An instrument used in receiving submarine cable messages, in which a spark is projected against some sensitized surface in an undulating line, which can be read by the operator. See "The Submarine Cable," Vol. VIII, p. 45.

Spectroscope. An instrument employed in spectrum analysis, perfected by Kirchhoff and Bunsen in 1859. This instrument "discloses the chemical nature and physical condition of any substance whose light is submitted to it." See "Revelations of the Spectroscope," Vol. III, p. 62; also, for star-spectra, Vol. V, p. 77.

Spinning. The process of making thread of uniform size from the fibers of cotton, flax, wool, silk, etc., for weaving purposes. See "An Industrial Revolution," Vol. IX, p. 5.

Spinning-frame. See Water-frame.

Spinning-jenny. A machine for spinning invented by James Hargreaves in 1767. See "Hargreaves and the Spinning-jenny," Vol. IX, p. 21.

Spinthariscopes. An instrument devised by Sir William Crookes for examining certain radio-active substances. See "The Nature of Emanations from Radio-active Bodies," Vol. V, p. 102.

Spontaneous Generation, Theory of. The obsolete doctrine that living matter may originate spontaneously out of non-living

TECHNICAL INDEX AND GLOSSARY

matter. See Vol. IV, p. 180; also, "Pasteur and the Germ Theory of Disease," Vol. IV, p. 217; also, "Life Problems," Vol. V, p. 220.

Static Machine. A machine for generating static, or frictional, electricity. It consists of a large circle of glass so arranged that its surface can be revolved rapidly against a suitable friction producer. Until the beginning of the nineteenth century static machines were the only kind of apparatus known for generating electricity. See "Progress in Electricity from Gilbert and Von Guericke to Franklin," Vol. II, p. 259.

Statics. The science that deals with stationary bodies in equilibrium or under conditions of stress or strain.

Steam. Water in a gaseous state. Water becomes gaseous at sea-level at a temperature of 212°F. , or 100°C.

Steamboat. See "Steam Engine" of the present index, and in particular "The Highway of the Waters," Vol. VII, p. 56.

Steam Engine. For the story of the development of the steam engine, see "Ctesibus and Hero: Magicians of Alexandria," Vol. I, p. 242; "Captive Molecules: The Story of the Steam Engine," Vol. VI, p. 79; "The Master Worker," Vol. VI, p. 110. For the application of steam in various fields, see "The Highway of the Waters," Vol. VII, p. 56; "The Steam Locomotive," Vol. VII, p. 119; "From Cart to Automobile," Vol. VII, p. 152.

Steam Locomotive. See "Locomotive" of the present index.

Steel. Is an alloy of iron and carbon; or a modified form of iron containing more carbon than wrought-iron and not as much as cast-iron, as a rule, although some mild steels contain as little carbon as wrought-iron. See "The Age of Steel," Vol. VI, p. 271.

Steelyard. An old-fashioned and primitive form of balance for weighing objects. The principle upon which the steelyard works is that of a lever of the first class.

Stethoscope. An instrument for listening to the sounds of the internal organs, particularly the lungs and heart. It consists essentially of a hollow tube, funnel-haped, which collects and concentrates the sound waves, just reversing the action of the megaphone. It was invented by Lænnec, a French physician, in 1815. See Vol. IV, p. 201.

Storage Battery. An electric battery for collecting and storing electricity. For the recent improvement in storage batteries, including the invention of Thomas A. Edison, see "Storage Battery Systems," Vol. VII, p. 188.

KEY AND INDEX

Storm Center. An area of low barometric pressure—an area where the air has become lighter than the air of surrounding regions. See "The New Science of Meteorology," Vol. III, p. 202.

Submarine Cable. The name given to submerged telegraph wires which are insulated and made waterproof. The first successful telegraphic cable seems to have been laid across the Hugli River, India, in 1838. See "The Submarine Cable," Vol. VIII, p. 30.

Submarine Signaling. A recent innovation in the field of navigation, by which the position of ships and other objects may be determined approximately by the use of a telephone receiver and the ringing of a submerged bell. See "Submarine Signaling," Vol. VII, p. 83.

Submarine Vessels. Vessels which run beneath the surface of the water, now very generally referred to as "submersibles." See "Submarine Vessels," Vol. VII, p. 93.

Suction. The phenomenon produced in any enclosed space in which the air is partially or completely exhausted. The word, as commonly applied, has no proper application, as the apparent "suction" from within is really a manifestation of the air-pressure from without. See "Suction and Pressure," Vol. VI, p. 64.

Sulphuric Ether. A light, inflammable fluid obtained from alcohol, which, when mixed with air and inhaled, produces insensibility. See "Painless Surgery," Vol. IV, p. 208.

Sun-spots. Changes on the surface of the sun, which were first recognized as such by Galileo, and enabled him to demonstrate that the sun itself revolves on its axis. For the discoveries of Galileo, see Vol. II, p. 77.

Telautograph. An instrument for the instantaneous transmission of a facsimile copy of writing or pen drawing. The apparatus was invented by Elisha Gray, who also named it.

Telegraph. At the present time the name is applied to the instrument for sending messages by means of electric signals. For the description of the development of modern telegraph systems, see "The Development of the Telegraph," Vol. VIII, p. 3.

Telephone. For the story of the development of the telephone, and telephone systems, see "The Development of the Telephone," Vol. VIII, p. 66.

Telescope. An optical instrument by the use of which dis-

TECHNICAL INDEX AND GLOSSARY

tant objects appear near, the invention of the Dutch optician Lippershey in the seventeenth century. In 1609 Galileo invented another type of telescope for astronomical observations. See Vol. II, p. 77. For later improvements in telescopes, see "Instruments of Precision in the Age of Newton," Vol. II, p. 252.

Telluric Structure. Pertaining to the structure of the earth. See "Solar and Telluric Problems," Vol. V, p. 205.

Telpherage Systems. The invention of Fleeming Jenkin, which consists of overhead cables hung on poles along which carriers of small capacity are hauled by electric motors. See "Traction in Mining," Vol. VI, p. 256.

Tetanus. The disease commonly known as lockjaw, is characterized by spasm of the voluntary muscles. It is caused by the tetanus bacillus, which was discovered by Nicolaier in 1884. Behring discovered an antitoxic serum which averts the attack of the disease when administered in time. See "Serum-therapy," Vol. IV, p. 240.

Textiles. Materials made by weaving together of threads to form a nearly solid surface, such as cloth, rugs, etc. The term does not apply to substances woven of wood, such as baskets. See "The Manufacture of Textiles," Vol. IX, p. 38.

Thermometer. A familiar instrument for determining the temperature. The most common form is that of an exhausted closed glass tube in which a column of mercury expands and contracts. The two kinds in more common use are the Centigrade, the freezing point of which is 0, and the boiling point 100; and the Fahrenheit, the freezing point of which is 32°, the boiling point 212°.

Thorium. An element discovered by the Swedish chemist Berzelius, and named by him after the ancient Scandinavian god Thor. It is one of the most valuable of the rare elements. The oxide of thorium is used in the preparation of gas mantles. See "The Incandescent Gas Mantle," Vol. VI, p. 208.

Toxine. Substances, generally of bacterial origin, which, when brought into the circulation, produce diseases of a distinct nature according to the nature of toxine. See "Serum-therapy," Vol. IV, p. 240.

Transformers. In electricity, are mechanisms for transforming a current of a certain voltage into one of higher or lower voltage. A "step-up" transformer changes a current of low voltage to one of higher voltage; a "step-down" transformer acts

KEY AND INDEX

in just the reverse manner from the "step-up" transformer. See "Step-up" and "Step-down" Transformers, Vol. VI, p. 198.

Transmutation of Species. The change of species in the process of evolution. Jean Baptiste de Lamarck (see Vol. IV, p. 150), early in the nineteenth century, called attention to this fact, and thus laid one of the foundation-stones to Darwin's theory of evolution. For a full treatment of the subject, see "Theories of Organic Evolution," Vol. IV, p. 140.

Treadmill. An implement for producing power, in which an animal or man by walking up a movable inclined plane transmits power. The animal, although continually walking, remains in the same spot, the platform receding at a rate corresponding to the walking rate of the animal. See Vol. VI, p. 60.

Trichina Spiralis. A parasite found in pork (and several of the lower animals), which may be transferred to the human system through the channel of the alimentary canal, and set up a severe and often fatal disease known as trichinosis. The parasite was discovered by James Paget, then a medical student, in 1833. See Vol. IV, p. 207.

Trichinosis. See "Trichina Spiralis."

Trophic Centers. Waller discovered that every nerve fiber, sensory or motor, has a nerve cell to or from which it leads, which dominates its nutrition, so that it can only retain its vitality while its connection with that cell is intact. Such cells he named trophic centers. See "Functions of the Nerves," Vol. IV, p. 249.

Tungsten Lamp. An incandescent electric lamp in which the filament is made of the metal tungsten (or some alloy) in place of the usual carbon filament. See "The Tungsten Lamp," Vol. VI, p. 234.

Turbine Engine. A steam engine in which the action of steam upon a shaft causes it to revolve, thus producing directly rotary motion. In the ordinary reciprocating engine the power has to be transformed into rotary motion by the intervention of a crank. See "Turbine Engines," Vol. VI, p. 124.

Turbine Water-wheels. A horizontal water-wheel made to revolve by the escape of water through orifices, under pressure derived from a waterfall. Probably the most powerful water turbines are those at Niagara Falls. See "Niagara in Harness," Vol. VI, p. 183; and "Running Water," Vol. VI, p. 70.

TECHNICAL INDEX AND GLOSSARY

Undulatory Theory of Light. According to this theory light is a kind of undulatory motion produced by the luminous body in the particles of an elastic, imponderable medium called the luminiferous ether, which is supposed to fill all space, and also the interstices of all bodies. See "Thomas Young and the Wave Theory of Light," Vol. III, p. 215.

Uranium. A metallic chemical element discovered by Klaproth in 1789, and first isolated by Peligot in 1842. Its atomic weight is 238.5, specific gravity 18.6, symbol U.

Valence (valency). The combination value or capacity of a chemical atom, in virtue of which it can unite with one only or with more than one atom equivalent to the hydrogen atom. See "Chemical Affinity," Vol. IV, p. 57.

Valves of the Veins. Structures in the lumen of veins which prevent the flow of blood backward away from the heart. They were discovered and described by the French anatomist, Charles Etienne (1503-1564). See Vol. II, p. 166.

Varnish. A solution of certain resins, such as mastic, lac, copel, asphalt, amber, benzoin, etc., capable of hardening without losing its transparency. Ordinary commercial varnish is a solution of resin in oil of turpentine. See "Varnishes," Vol. VIII, p. 316.

Vitagraph. A moving-picture machine similar to the kinetoscope, patented by Thos. A. Edison in 1891. See "Chronophotography—Moving Pictures," Vol. VIII, p. 248.

Vitalists. Followers of a system of medicine championed by Paul Joseph Barthez in the eighteenth century. They assumed that there was a "vital principle," of unknown nature, but differing from the thinking mind, or the soul, which was the cause of all the phenomena of life. See "Animists, Vitalists, and Organicists," Vol. IV, p. 184.

Vitascope. See "Vitagraph" of the present index.

Volt. The unit of electro-motive force. See "Electricity" of the present index.

Vortex Atom. See "Vortex Theory."

Vortex Theory. A conception that the atoms and molecules of physical science may be vortex rings or filaments, or combinations of these, in the universal ether. See "Physical Problems," Vol. V, p. 213.

KEY AND INDEX

Walking Beam. A beam, or bar, used on a certain type of steam engine to convert the reciprocal motion of the piston into rotary motion. At the present time the walking beam is little used except on side-wheel river steamers. See "Final Improvements and Missed Opportunities," Vol. VI, p. 102.

Water. A universally diffused liquid, with the formula H_2O (two atoms of hydrogen and one of oxygen). The chemical composition of water was discovered in 1781 by Henry Cavendish. James Watt is also credited with priority of this discovery, but Cavendish's claim is fully established. See Vol. IV, p. 14.

Water Engines. See "The Work of Air and Water," Vol. VI, p. 70.

Water-frame. The name given Arkwright's spinning-frame. See Vol. IX, p. 25.

Watermills. Mills driven by water-power appear to have been introduced in the time of Mithridates, Julius Cæsar, and Cicero. When the Goths besieged Rome in 536 and cut off the water supply for running the mills the Romans constructed floating mills on the Tiber. Mills driven by the tide existed in Venice as early as 1078. See "The Work of Air and Water," Vol. VI, p. 70.

Water-motor. Any water-wheel or turbine run by water. In 1838 Lord Armstrong had a water-motor constructed along lines similar to the modern steam turbine engine. Its efficiency was ninety-five per cent, and it developed five horse-power at thirty revolutions per minute. See Vol. VI, p. 70.

Water-wheels. See "Watermills" of the present index.

Weaving. The art of producing textile fabrics, such as cloth, network, lace, etc., from a combination of threads on a loom. Hand weaving was known in prehistoric times, but the modern art of weaving dates from John Kay's invention of the flying shuttle (Vol. IX, p. 42), in 1738, and Dr. Cartwright's invention of the power loom about 1784 (Vol. IX, p. 43). See "An Industrial Revolution," Vol. IX, p. 5; and "The Manufacture of Textiles," Vol. IX, p. 38.

Wedge. A special application of the inclined plane, consisting of a very acute-angled triangular prism of hard material driven between objects to separate them. The screw is also an example of the use of the inclined plane, but is used for an entirely different purpose from the wedge, the object of its use being to hold objects together.

Wheel. A circular disk or frame turning on an axis. The

TECHNICAL INDEX AND GLOSSARY

wheel is a lever of the first class, of which the axle constitutes the fulcrum. See "Wheels and Pulleys," Vol. VI, p. 32.

Windlass. A modification of the wheel and axle, consisting of a cylinder rotating on an axis propelled by a long handle, or handles, a rope or chain being wound about the cylinder. It is a lever of the second class, the axle representing the fulcrum.

Windmills. Machines utilizing the pressure of the wind as a motive power. The usual type of windmill consists of a series of inclined planes, each of which forms one of the radii of a circle, or spokes of a wheel, to the axle of which a gearing is adjusted by which the power generated is utilized. Windmills seem to be of comparatively recent origin, as there is no authentic record of their use prior to about 1100 A.D. See "The Work of Air and Water," Vol. VI, p. 62.

Wind. Air naturally in motion at the earth's surface. All winds come under the influence of the earth's rotation in such a way as to be deflected from their course, and hence take on a gyratory motion. See Vol. III, p. 200.

Wireless Telegraph. In the modern sense, an electric telegraph which utilizes electro-magnetic waves ("Hertzian waves") in the ether in place of wire, or other conductors, for sending and receiving messages. There are several other methods of using the electric current besides this, but none that are effective for long distances. See "Wireless Telegraphy," Vol. VIII, p. 47.

Wireless Telephone. A telephone which utilizes Hertzian waves in the ether in place of wire conductors of the electric current. The first practical wireless telephone system was the invention of Dr. Lee DeForest, an American, which was exhibited publicly in 1907. See "The Wireless Telephone," Vol. VIII, p. 88.

BIOGRAPHICAL INDEX

(The matter under this alphabet constitutes at once a Biographical Reference Index and a condensed Biographical Dictionary of the Important names in every department of science. The figures following the names refer to the text by volume and page. The reading matter is complementary to the matter of the Technical Index and Glossary, and of the General Index, and to some extent supplementary of the text itself.)

Abd-el-Letif, or Abd-ul-Latif, ii, 21. Born at Bagdad, 1162; died at Bagdad, 1231. Arabian scholar and author of multifarious acquirements. He labored unceasingly in his early years to acquire all the knowledge of his age. Lived at Damascus and spent many years in Egypt, of which country he has left an excellent and accurate account. Devoted much time to study of medicine.

Adams, John Couch, iii, 42, 48. Born at Cornwall, England, 1819; died at Cambridge, 1892. At an early age he displayed a great aptitude for mathematics and became a mathematical tutor at Cambridge. In 1841 he set himself to the task of discovering the cause of the irregularities in the motion of the planet Uranus, and in October, 1844, wrote an account of the existence of a new planet and gave its location. This, unfortunately, he did not publish. Leverrier, in France, took up the same subject in 1845, and announced the existence of Neptune in November of that year. Hence he obtained the whole honor of the discovery, which Adams should have shared. In 1858 Adams was appointed professor of mathematics at St. Andrews, Cam-

KEY AND INDEX

bridge, and shortly afterward became Lowndean professor of astronomy at the same university.

Aëtius, ii, 31. ("The Atheist.") Born at Antioch; died at Constantinople, 367. He was born a slave. Studied medicine and theology, became a deacon, and developed the doctrine known as Aëthian heresy, which carried the ideas of Arius to their logical issue. Constantine banished him from Antioch for his Arian tendencies. The Emperor Julian made him a bishop, but he died in disgrace owing to his profligate habits.

Agassiz, Jean Louis Randolphe, iii, 147. Born in Switzerland, 1807; died at Cambridge, Mass., 1873. One of the most distinguished of modern naturalists. While at the universities of Heidelberg and Munich comparative anatomy was the special subject of his study, but he became more interested in ichthyology, when the Spix collection of fish was left in his care (1826). Studied and wrote much on fish and their fossil remains. 1847 published "The System of Glaciers," which advanced some new and original views in geology. * Came to United States in 1846, and afterward became professor at Harvard. In "Outlines of Comparative Physiology" he holds to the belief in the special creation of species, and opposed the Darwinian theory.

Airy, Sir, G. B., vii, 11. Born at Alnwick, Northumberland, July 27, 1801; died at Greenwich, Jan. 2, 1892. Director of the Greenwich Observatory and Astronomer Royal, 1836-1881. First to suggest the use of permanent magnets on ships for compensating the influence of iron structures upon the compass.

Albategnius, Mohammed ben Jabir, ii, 15.

BIOGRAPHICAL INDEX

Born at Mesopotamia cir. 850; died, 929. The greatest of Arabian astronomers, who discovered the motion of the sun. Made observations steadily for over 60 years at the Euphrates and at Antioch in Syria. Wrote "The Science of the Stars." Improved Ptolemy's table and came very close to ascertaining the obliquity of the ecliptic. His observations were the foundations of the Alphonsine table of the Moon's motion.

Albertus Magnus (Albert Count of Bollstädt), ii, 127. Born at Swabia, 1193 or 1205 (accounts vary); died at Cologne, 1280. Became Dominican friar after studying at Padua, and taught in many places. Went to Paris 1230, and devoted himself to spreading the doctrine of Aristotle in spite of the prohibition of the Church. In 1260 was made Bishop of Ratisbon. 1262 retired to a convent at Cologne and devoted rest of life to literary pursuits.

Albucasis (or Albucasim), ii, 25. Born near Cordova, Spain; died, 1106. Famous Arabic physician and author of "Al-Tasrif," a medical encyclopædia, containing the best treatise on surgery that has come to us from antiquity.

Alcmaëon, i, 126. Born at Crotona, Italy, second half of Sixth Century B.C. Greek physician and naturalist. Was the first man to practice dissection, by which he made many valuable discoveries in anatomy. Author of "On Nature."

Alfonso X, ii, 17. Born in 1221; died in 1284. King of Leon and Castile. Most learned prince of his time. The chief debt of science to him is the Alfonsine Tables, which he had compiled by fifty of the most celebrated astronomers of

KEY AND INDEX

the age. Their purpose was to correct and replace the Ptolemaic planetary tables, which were full of errors.

Alhazen (full name, Abu Ali Al-Hasan Ibn Alhasan), ii, 18. Born at Bassora cir. 965; died at Cairo cir. 1039. Arabian physicist and naturalist. Wrote important work on Optics. Famous for the geometrical problem bearing his name.

Amici, Giovanni Battista, iv, 112. Born at Modena, 1786; died at Florence, 1864. Italian astronomer, director of the Florence Observatory. He designed and constructed many valuable astronomical and physical instruments. Was also interested in botany.

Ampère, André, iii, 239, iv, 43. Born at Lyons, 1775; died at Marseilles, 1836. French mathematician, physicist and naturalist. Taught in several places, and finally with great distinction at the École Polytechnique, Paris. Science is most indebted to him for his researches in electricity and magnetism. Invented the astatic needle. Showed identity between magnetism and electricity. Showed attraction and repulsion in parallel conductors of electricity, with currents flowing in same or opposite direction. The unit of strength in electric current is named after him.

Anaxagoras, i, 240. Born in Ionia cir. 500 B.C.; died at Lampsacus, 428. Taught at Athens. The last Greek philosopher of the Ionian school. His great service to the world was that he turned philosophy from thought about things to thought in itself. He defined a new principle, Mind as acting on matter, which

BIOGRAPHICAL INDEX

dualistic theory was further developed by Plato and Aristotle. He was banished from Athens for the impiety of his explanation of natural phenomena. He may have been guilty of disrespect for the gods, but he came very near to being right in his explanation of the causes of the rainbow, the Moon's light, the winds, and the origin of sound. He died a wanderer in exile.

Anaximander, i, 109. Born at Miletus, 610 B.C.; died in 546 B.C. Successor of Thales as head of the Ionian School; was a great mathematician and astronomer, as well as philosopher. Taught the obliquity of the ecliptic, and introduced the sun-dial into Greece. It is believed that he invented geographical maps. Conceived the universe as a series of concentric cylinders. As a philosopher he believed the phenomenal world to proceed from some indefinite or indeterminate principle, similar, perhaps, to the chaos of other philosophers. There was no such thing as creation out of nothing, but the atoms of primary matter change their relative positions through some innate power and become the contents of the phenomenal world.

Anaximenes, i, 109. Born at Miletus, flourished Sixth Century, B.C. He taught that air was the primary form of matter, and that all things were formed from it by compression.

Arago, Dominique François, iii, 67. Born at Estagel, France, 1786; died at Paris, 1853. French physicist and astronomer. Became professor of analytical geometry and geodesy at the École Polytechnique, Paris, but afterward devoted more attention to astronomy, electricity,

KEY AND INDEX

galvanism and the polarization of light. He proved the value of the undulatory theory of light. He continued Oersted's discoveries in electromagnetism, by showing that an unmagnetized bar of steel or iron could be magnetized by a voltaic current. He also showed the fact of magnetization by rotation.

Archimedes, i, 196. Born cir. 287 B.C.; killed at capture of Syracuse, 212 B.C. Syracusan mathematician, the most famous of all antiquity. Developed pure geometry, and applied mathematical theories to mechanics. Invented hydraulic screw, and is given credit for explaining principle of lever. Constructed catapults and other engines which delayed the fall of Syracuse (212 B.C.).

Aristarchus of Samos, i, 212. Lived first half Third Century, B.C. Alexandrian astronomer. Made many observations of which we know only a few. He calculated the relative distances of sun and moon from earth. His theory of calculation was correct, but inaccurate in practice. It is said that with the Pythagoreans he believed the earth to revolve around the sun.

Aristotle, i, 82. Born at Stagira, 384 B.C.; died at Chalcis, 322 B.C. Greek philosopher and scientist. After living in various places and teaching, he settled at Athens and opened the so-called peripatetic school. As a scientist he treated of astronomy, zoology, mechanics and physics at considerable length. His two chief mental faculties were great aptitude for observation, and a logical method, which lay in the assiduous collection of facts, and the drawing of inductions from them. In this he com-

BIOGRAPHICAL INDEX

pletely discarded the pre-existing "ideas" or "forms" of Plato. His "System of Logic" is the basis of that used at the present day. He was for three years the tutor of Alexander the Great.

Arkwright, Sir Richard, ix, 17. Born at Preston, England, Dec. 23, 1732; died at Cromford, Derbyshire, England, Aug. 3, 1792. Invented the cotton-spinning frame, or "water-frame," a device that revolutionized spinning. He began life as a barber, and his early inventions were made in leisure hours when not working at his trade. He amassed an enormous fortune as a result of his invention, and in 1786 was knighted by George III.

Arnold of Villanova, ii, 34. Born cir. 1240; died in 1313. Nationality unknown. A physician, alchemist, and astrologer, who taught at Paris, Barcelona, and Montpellier. He has been incorrectly credited with the discovery of hydrochloric, nitric, and sulphuric acids. These were certainly known before his time.

Arrhenius, Svante. Born at Upsala, 1859. Swedish physical chemist, professor in the University of Stockholm. His theory of electrolytic dissociation, which he has established, is one of the most important of recent contributions to science. It is that if a current is passed through a substance whose aqueous solution is capable of conducting electricity, it is broken up in solution into parts of the composing elements charged, some with positive and others with negative electricity. The existence of positive and negative "ions" has explained a number of chemical phenomena hitherto incomprehensible.

Arzachel, ii, 16. Born in Spain, cir. 1050.

KEY AND INDEX

Arabian astronomer. Discovered the obliquity of the ecliptic and compiled the "Toledo" astronomical tables.

Avenbrugger, Leopold, iv, 200. Born at Gratz, 1722; died at Vienna, 1809. Viennese physician who introduced the method of percussion diagnosis, by applying ear to the chest and noting the result of hand taps on the patient. Also an insanity expert.

Avenzoar (Abu Merwan Abelmalec ibu Zohr), ii, 26. Born at Seville, 1072; died at Seville, 1162. A Spanish-Arabian physician who labored hard to have the experimental method applied to study of medicine.

Averrhoes, ii, 10. Born at Cordova, cir. 1126; died at Morocco, 1198. Spanish-Arabian philosopher and jurist. Was physician to Caliph of Morocco. He was an ardent advocate of the Aristotlean method, as applied to medical and other sciences.

Avicenna, Arabian "Prince of Physicians," ii, 24. Born near Bokhara, 980; died at Ispahan cir. 1037. Arabic physician and philosopher. After an adventurous existence, he finally settled as court physician to Ala Adda-ula at Ispahan. His great work "Kanun fi'l Tibb," is a system of medicine still highly regarded in the Orient. Was a disciple of Aristotle.

Avogadro, Amadeo, iv, 43. Born at Turin, 1776; died at Turin, 1856. Italian physicist. Professor at Turin. Formulated the famous rule known by his name. It is one of the fundamental principles of chemistry—equal volumes of gas contain equal number of molecules under same conditions of pressure and temperature.

BIOGRAPHICAL INDEX

Bacon, Francis, ii, 192. Born at London, 1561; died at Highgate, 1626. English philosopher and statesman. Educated at Cambridge, was attached to Embassy in France, 1576. Entered Parliament, 1584. Knighted, 1603; held many political offices up to Lord Chancellor, 1618, and tried for bribery, removed and fined, 1621. He was a great reformer of methods of scientific investigation, and one of the chief founders of modern inductive science. Chief works, "Novum Organum" and "Advancement of Learning."

Bacon, Roger, ii, 44. Born at Ilchester, cir. 1214; died at Oxford (probably) 1294. English monk and philosopher. Studied at Oxford, Paris, returned to England and entered Franciscan order at Oxford, where he carried on researches in alchemy and optics. Was removed to Paris, 1257, after having been accused of unorthodoxy and dealing with the black art. All writing materials and instruments were taken from him. Despite the Franciscan prohibition, he prepared his "Opus Majus" at the request of Pope Clement IV. This was an encyclopædia of all the science and knowledge of the time. Ten years after Clement's death he was free to do as he liked, but was imprisoned again by Pope Nicholas III, and his books forbidden to be read. He had found out much in the way of chemistry and by some is credited with knowing of the existence of gunpowder. He studied much in optics and corrected many errors in the calendar.

Baglivi, Giorgio, iv, 182. Born at Ragusa, Sicily, 1669; died at Rome, 1707. Italian physician

KEY AND INDEX

of Armenian extraction. Went to Rome and was appointed Professor of Anatomy at the College di Sapienza. He was the first to propound the medical doctrine of "solidism," according to which the primary seat of disease is in the solid parts of the organism, and not in the fluid, as was believed up to that time.

Bastian, Henry Charlton, iv, 180. Born at Cornwall, 1837. English physician and biologist. Professor in University College, London. Noted nerve specialist. Strong defender of the doctrine of spontaneous generation.

Becquerel, Alexandre Edmond, viii, 235. Born at Paris, 1820; died at Paris, 1891. French physicist, son of Antoine César. Member of Academy of Science, 1863. In 1878 succeeded his father as Professor of Physics at the Conservatoire des Arts et Métiers. Researches in electricity, optics and photography. Well known for his work on the Solar spectrum.

Becquerel, Antoine Henri, v, 98. Born at Paris, 1852; died at Paris, 1908. French physicist, Professor of Physics in the École Polytechnique, Paris. His researches have been mainly concerned with optics, chiefly the invisible radiation from uranium, known as the Becquerel rays.

Behring, Emil Adolf, iv, 242. Born at Hansdorf, Prussia, 1854. German physician who in 1895 became director of the Hygienic Institute at Marburg. Most noted for his discovery of diphtheria serum. He made a special study of the question of immunity from disease.

Barthez, Paul Joseph, iv, 185. Born at Montpellier, 1734; died at Paris, 1806. French physician. Became Professor of Medicine Montpel-

BIOGRAPHICAL INDEX

lier University, 1761. He formulated a new theory of life—that of a vital principle in the living organism, which is different from both the thinking mind and the physical forces of the body. The life of each separate organ is a particular manifestation of the vital principle. He made no experiments to substantiate his views.

Bell, Alexander Graham, viii, 73. Born at Edinburgh, 1847. American inventor and scientist. Educated in Great Britain, came to Canada, 1870. He became greatly interested in his father's system of instruction for the deaf and dumb, and after his appointment as Professor of Vocal Physiology at Boston University, 1872, began the experiments which led to the invention of the telephone. Has also invented the photophone, which transmits sounds by waves of light; also the graphophone.

Bell, Alexander Melville, viii, 78. Born at Edinburgh, 1819. Scottish-American educator. After teaching at Edinburgh and London Universities came to Queen's College, Kingston, Canada, and later, 1881, removed to Washington, D. C. Inventor of the visible-speech system for teaching deaf-mutes to speak.

Bell, Sir Charles, iv, 249. Born at Edinburgh, 1-774; died in 1842. Scottish surgeon, anatomist and physiologist. In early life practiced and lectured Edinburgh and London. Made a special study of gunshot wounds during the Napoleonic wars. 1826 became head of medical department, London University. His principal work and practice was in connection with nervous diseases, upon which he was a great authority.

KEY AND INDEX

Bernard, Claude, iv, 137. Born at St. Julien, 1813; died at Paris, 1878. French physiologist. Educated in Paris, he succeeded Magendie as Professor of Experimental Physiology at the Collège de France, 1855, having been chosen for the Academy of Science the previous year. Founded the Société de Biologie, and was its president from 1867. His most distinguished work was in connection with the secretions of the alimentary canal, and the action of the nervous system on them. He was the first to show that the pancreatic juice was the true agent of the digestion of fatty substances. When he died his funeral was conducted at the public expense, an honor never before given to a man of science.

Berosus, i, 58. Lived and wrote first half of Third Century, B.C. Greek historian, a priest of Belus at Babylon. Wrote three books on Babylonian history, which are of interest for their agreement with the early Hebrew records.

Berthelot, Pierre Eugène Marcellin. Born at Paris, 1827; died at Paris, 1907. French chemist, educated in Paris, and devoted his life to research in organic chemistry. His first achievements attained in 1854, when he gave his account of the artificial reproduction of natural fats, a matter which has since been of great importance to industry. In 1865 a chair was created for him at the Collège de France. In later years he materially increased our knowledge of every class of carbon compound, and made important experiments with explosives and aniline dye-stuffs. In 1889 was perpetual secretary of the Academy of Science. Has also taken an interest in politics.

BIOGRAPHICAL INDEX

1881 created lifelong member of Senate. 1886-1887, Minister Public Affairs. 1895-1896, Minister Foreign Affairs.

Berthollet, Count Claude Louis, iv, 41. Born at Savoy, 1748; died at Paris, 1822. French theoretical chemist. After graduation from Turin University went to Paris as physician to Duke of Orleans. Applied himself to chemistry, working out the theories of Lavoisier and Priestly. Was the first to discover the composition of ammonia. In 1794 was made professor at the École Normale. His visit to Egypt with Napoleon's expedition led to the foundation of the Institute of Cairo. With Lavoisier, he devised the system of chemical nomenclature still in the main employed.

Berzelius, Johan Jakob, iv, 41. Born at Westerlosa, Sweden, 1779; died at Stockholm, 1848. Swedish chemist. After graduation at Upsala, devoted himself to chemistry. 1807 became Professor of Medicine and Pharmacy at Stockholm. Accomplished a prodigious amount of work in chemistry. His discoveries and views gave a firm foundation to inorganic chemistry. He established the laws of combination. Famous for his analyses and discoveries (including several elements) with the blow-pipe. Interest in his theory, that chemical combination was the result of electrical attraction, although abandoned for many years, has recently been revived owing to the researches of his famous fellow-countryman, Arrhenius, although considerable modification of it is necessary.

Bessel, Friedrich Wilhelm, iii, 42. Born at Minden, 1784; died at Königsberg, 1846. Ger-

KEY AND INDEX

man astronomer; has been called with some reason the father of modern observational astronomy. Became astronomer in opposition to his parents' wishes, and in 1810 was Professor of Astronomy and Observatory Director at Königsberg. He determined the parallax of 61 Cygni, and made the first measurement of distance of a star from the solar system. He was one of the first to consider the personal equation of astronomers.

Bessemer, Sir Henry, vi, 291. Born at Charlton, England, 1813; died in 1898. English inventor. He turned his attention at an early age to mechanical inventions. Devised a method of impressing stamp of internal revenue office in order to prevent forgeries. Made a gold paint which was very successful commercially. During Crimean War turned his attention to making stronger cannon. He first produced an improved form of cast-iron, and finally steel by bringing air into contact with molten iron. The Bessemer process had a marked effect in cheapening cost of steel, and making it available for all kinds of engineering work. Invented also a method of compounding graphite into a solid block for pencil making, a method of type-casting, and several other processes.

Bichat, Marie François, iv, 107. Born at Thoirrette, 1771; died at Paris, 1802. French anatomist and physiologist. Ended his brilliant career at an early age through overwork. He lectured on anatomy and was physician in the Hotel Dieu, Paris. He was the founder of the science of pathological anatomy, and was the first to

BIOGRAPHICAL INDEX

show that the different organisms have membranes and tissues in common.

Biot, Jean Baptiste, iii, 168. Born at Paris, 1774; died at Paris, 1862. French physician and astronomer. Forsook the army for science. 1880 became Professor of Physics in the Collège de France. Assisted in measuring the arc of the meridian as the basis for the metric system. Associated with Arago in many of his experiments, and with Gay-Lussac made the first balloon ascension for scientific purposes. Made valuable contributions with regard to polarization of light.

Birch, Samuel, i, 27. Born at London, 1813; died at London, 1885. English archæologist. Keeper of Oriental antiquities in the British Museum. Made a special study of the Egyptian hieroglyphics.

Black, Joseph, iv, 12. Born at Bordeaux, France, 1728; died at Edinburgh, 1799. Scottish chemist. In 1754 took his degree in medicine at Edinburgh. Was professor of anatomy and Lecturer on Chemistry at Glasgow. 1766 was made Professor of Chemistry at Edinburgh. He first clearly established the existence of carbonic acid gas, and evolved the theory of latent heat, which opened the way for Watt's improvements in the steam-engine.

Bond, William Cranch, iii, 44. Born at Portland, Me., 1789; died at Cambridge, Mass., 1859. A self-educated American astronomer who attracted much attention by his discoveries at his private observatory, Dorchester, Mass. Supervised the construction of Harvard Observatory and became its director. Invented a method of

KEY AND INDEX

measuring time to the very small fraction of a second. Noted for his work in stellar photography.

Boerhaave, Hermann, iv, 182. Born near Leyden, 1668; died at Leyden, 1738. Dutch physician. Educated for the ministry. He began in 1690 to study medicine, in which he was largely self-educated. Rose in the profession until he became Professor of Medicine at Leyden (1709). He devised a new system of medicine, which he explained in two great works. Also an investigator in botany and chemistry. His fame as a physician was world-wide.

Borelli, Giovanni Alphonse, ii, 188. Born near Naples, 1608; died at Rome, 1679. Italian physician and mathematician. Founder of the iatrophysical school. Educated in Florence, professor in Pisa and Messina. Driven from latter place for participation in political revolt, he spent remaining years in Rome. Seems to have been first to discover parabolic paths of comets. Wrote book on animal motion, attempting to apply principles of mechanisms to movements of animals.

Boscovich, Roger Joseph, iii, 293. Born at Ragusa, Dalmatia, 1711; died at Milan, 1787. Italian astronomer and mathematician. Joined Jesuit order. Taught in Rome and afterward in Paris. In 1758 advanced a molecular theory of matter. Wrote on many subjects in physical science, and was first to introduce Newton's theories into Italy. Died insane.

Bose, George Matthias, ii, 274. Born at Leipsic, 1710; died at Magdeburg, 1761. German physicist and physician. Taught in Leipsic, and

BIOGRAPHICAL INDEX

after 1738 Professor of Physics in the University of Wittenberg. At the bombardment of that city, 1760, he was taken as hostage by the Prussians to Magdeburg, where he died the following year. Made researches and wrote on astronomy, physics, and electricity.

Boyle, Robert, ii, 205. Born at Waterford, Ireland, 1627; died at London, 1691. Irish physicist and chemist. Studied at Eton and on the Continent. Devoted himself to science. One of the originators of the Royal Society. In 1654 settled at Oxford and experimented in pneumatics, improving the air-pump. Was very active in religion. Formulated independently of Mariotte the law of gases known by his name. Succeeded Bacon in the reputation of being the greatest English scientist of his time.

Bradley, James, iii, 13. Born at Sherborne, England, 1693; died at Chalford, 1762. English astronomer. Educated at Oxford. 1721 appointed to Savilian Chair of Astronomy, Oxford. 1729 announced discovery of aberration of light. 1742 appointed Astronomer Royal and made many important discoveries at Greenwich, among them nutation of the earth's axis. By procuring new instruments, he made the Royal Observatory the first of the great modern observatories. Newton called him "the best astronomer in Europe."

Brahe, Tycho, i, 217. Born at Knudstrup, Sweden, 1546; died at Prague, 1601. Danish astronomer, educated at Copenhagen. Destined for law, but persisted in studying astronomy, in which he made many discoveries. 1572 discovered a new and brilliant star in Cassiopeia.

KEY AND INDEX

Frederick II of Denmark took him under his protection, and built the famous Uranienborg Observatory for him, where he worked assiduously for over twenty years. After Frederick's death he went to Prague on invitation of Emperor Rudolph II, but died soon after. He rejected the Copernican system.

Braid, Dr. James, iv, 269. Born at Fife, Scotland, cir. 1796; died at Manchester, England, 1860. English physician. Educated at Edinburgh, settled in Manchester. Noted for his researches on the subject of animal magnetism. Invented the term "neurohypnotism," which was shortened into hypnotism.

Brennan, Louis, vii, 195. Born at Castlebar, Ireland, Jan. 28, 1852. Engineer and inventor. First came into prominence as the inventor of a torpedo for the British Government. Later invented the practical mono-rail gyro car, public exhibitions of a full-sized model of which were given in 1909.

Brewster, Sir David, iv, 110. Born at Jedburgh, Scotland, 1781; died at Montrose, 1868. Scottish physicist. Educated for Church of Scotland at Edinburgh, but turned his attention to science—especially optics. Invented the kaleidoscope, 1816. Edited "Edinburgh Encyclopædia," and assisted in establishing the "Edinburgh Philosophical Journal"; one of the chief originators of the British Association for the Advancement of Science. Discoverer of the polarization of light. 1819 chosen principal of Edinburgh University.

Broca, Dr. Paul, iv, 272. Born at Sainte Foy, 1824; died at Paris, 1880. French physician and

BIOGRAPHICAL INDEX

anthropologist. Studied in Paris, and taught there in several places. In 1847 began a thorough study of anthropology. 1859 founded the Anthropological Society of Paris. 1876 founded the *Ecole d'Anthropologie*, now the Anthropological Institute. Made many valuable contributions to anthropology. In 1861 he discovered the location of the seat of articulate speech in the brain.

Brown, Robert, iv, 115. Born at Montrose, Scotland, 1773; died at London, 1858. Scotch botanist. Educated Aberdeen and Edinburgh. Entered British Army as assistant-surgeon. Resigned commission, 1800, to study botany. Went to Australia and brought back over 4,000 specimens of plants, most of them new to science. Adopted the Jussien natural system and helped in its general substitution for that of Linnæus. In 1810 took charge of the Bank's collection, which was afterward transferred to British Museum, where he became keeper of the botanical department.

Brush, Charles Francis, vi, 226. Born at Euclid, Ohio, March 17, 1849. His inventions are largely responsible for modern arc-lighting systems. In 1881 the French Government decorated him for his work in electricity, and in 1900 the American Academy of Arts and Sciences awarded him the Rumford medal.

Brugsch, Hermann Karl, i, 28, iv, 187. Born at Berlin, 1827; died at Berlin, 1894. German Egyptologist. Visited Egypt several times for archæological purposes. Professor at Göttingen University. Director of the Egyptological School at Cairo. 1881, succeeded Mariette as

KEY AND INDEX

keeper of the Bulak collection. Director of the Egyptian Museum, Berlin. Wrote valuable History of Egypt.

Brunel, Isambard K., vii, 77. Born at Portsmouth, 1806; died at London, 1859. English engineer, son of Sir M. I. Designer of the "Great Western," first steamer built to cross Atlantic, and "Great Britain" (first iron ocean steamship). Also "Great Eastern." 1833, appointed chief engineer Great Western Railway, and designed a large part of the road. Engineer of many famous constructions.

Budge, Dr. Ernest A. Wallis, i, 28. Contemporary English archæologist. Keeper of the Egyptian and Assyrian antiquities, British Museum. Educated at Cambridge, gave special attention to Semitic languages. Has conducted excavations in Egypt and Mesopotamia, and has written a great deal on the history and inscriptions of those countries.

Buffon, George Louis Leclerc, Comte de, iv, 149. Born at Montbard, Burgundy, 1707; died at Paris, 1788. Studied law at Dijon, but gave it up for science. Interested at first in astronomy and mathematics, but finally his talents turned definitely toward zoology, and he set to work at a collection and systematization of all the facts of physical nature. He was not quite equal to the task, but his "Natural History" marks an epoch in the study of natural science, although it has no scientific value, as most of his views and theories have been shown to be false.

Bunsen, Robert Wilhelm, iv, 69. Born at Göttingen, 1811; died at Heidelberg, 1899. German chemist. Educated Göttingen, where he devoted

BIOGRAPHICAL INDEX

himself especially to zoology and chemistry. Studied also at Paris, Berlin, and Vienna. Taught various places, and finally appointed, 1852, Professor of Chemistry, at Heidelberg. Invented the magnesium light, 1860. He and Kirchhoff discovered spectrum analysis, which have been the means of great advances in astronomy and chemistry.

Burnham, S. W., iii, 59. Born at Thetford, Vermont, 1838. American astronomer. A stenographer by profession, he became interested in astronomy and made a special study of double stars, of which he has recorded over twelve hundred, his powers of observation being very extraordinary. Professor of Practical Astronomy, University of Chicago.

Calmette, Léon Charles, v, 184. Born at Nice, 1863. French bacteriologist. Has made many investigations especially relating to serum poisoning at the Pasteur Institute, Paris. Also investigations in tuberculosis. Has established Pasteur and anti-tuberculosis institutions in various parts of the world.

Calvin, John, ii, 168. Born at Noyon, Picardy, 1509; died at Geneva, 1564. French religious reformer. Studied at Paris, Orleans, and Bourges. Joined the Reformation about 1528. After various vicissitudes, settled at Geneva, when he finally assisted in establishing a theocratic government and preached religious doctrine, which, while severe, had great influence in the history of the Protestant religion.

Canton, John, ii, 295. Born at Stroud, England, 1718; died at London, 1772. English physicist. He made the discovery almost simul-

KEY AND INDEX

taneously with Franklin that some clouds were charged with positive and others with negative electricity. He first showed the compressibility of water, and measured the quantity of electricity stored in Leyden jars.

Carnot, Sadi, iii, 255. Born at Paris, 1796; died at Paris, 1832. French physicist. Served until 1828 in the Corps of Engineers, where he found time for research, and worked over the general theory of the heat engine. His works mark the beginnings of the science of thermodynamics.

Carpenter, William B., iv, 122. Born at Exeter, England, 1813; died at London, 1885. English physiologist. Graduate, Edinburgh, 1839, wrote many books on physiology. Registrar, London University, 1856-1879. Made valuable contributions to the subject of ocean circulation.

Cartwright, Dr. Edmund, ix, 44. Born at Marnham, Nottingham, England, April 24, 1743; died at Hastings, England, Oct. 30, 1823. An English clergyman who devoted much time to mechanical inventions. His greatest invention, the power loom, revolutionized weaving.

Cassini, Dominic, iii, 13. Born near Nice, 1625; died at Paris, 1712. Italian-French astronomer. Professor of Astronomy at Bologna, and afterward director Paris Observatory, which post was held by the family for four generations. His work was principally connected with observations on the planetary system, orbits, etc. He assisted in showing the earth to be a spheroid.

Caus, or Caulx, Salomon de, vi, 83. Born at Dieppe, 1576; died at Paris, June 6, 1626. French engineer. In 1615 he published a work entitled

BIOGRAPHICAL INDEX

“Causes of Kinetic Energy,” in which he described an apparatus for forcing up water by a steam fountain. For this Arago claimed for de Caus the invention of the steam-engine.

Cavendish, Henry, iv, 15. Born at Nice, 1731; died at London, 1810. English physicist and chemist. Educated at Cambridge, devoted his entire life to science, and having inherited considerable means, remained unmarried and lived the life of a recluse. Discovered composition of water and devised a method for determining density of earth. Made many investigations of properties of carbonic acid gas.

Celsius, Anders, vi, 14. Born at Upsala, 1701; died at Upsala, 1744. Swedish astronomer. Professor at Upsala. Took part in the French expedition, 1737, to measure a degree of the meridian in the polar regions. Presented the first idea of the centigrade thermometer.

Celsus, Aulus Cornelius, ii, 40. Probably lived in the reign of Tiberius. Latin physician. Introduced the Hippocratic systems among the Romans. Wrote on other subjects besides medicine. His writings on surgery are especially valuable, and contain much about the work and opinions of the Alexandrian School.

Chabas, François Joseph, i, 28. Born at Briançon, 1817; died at Versailles, 1882. French Egyptologist, although engaged throughout life in business as a wine merchant. Declined a chair in the Collège de France. Became a leading authority on the ancient Egyptian language and translated many of the hieroglyphic and hieratic writings.

Chambers, Robert, iv, 162. Born at Peebles,

KEY AND INDEX

Scotland, 1802; died at St. Andrews, 1871. Scotch publisher and writer. Set up as a bookseller in Edinburgh, 1818, and in 1832 started the famous publishing house of W. & R. Chambers, with his brother. Wrote "Vestiges of the Natural History of Creation" (1844), which prepared the way for the acceptance of Darwin's theories.

Champollion, Jean François, i, 27, iv, 290. Born at Figeac, France, 1790; died at Paris, 1832. French Egyptologist. 1807, went to Paris to pursue Oriental studies. 1814, appointed Professor of History at Lyceum of Grenoble. Succeeded in deciphering Egyptian hieroglyphics, which achievement involved him in a controversy with Thomas Young on the question of priority of discovery, although it is now generally conceded that Champollion worked independently of Young.

Charcot, Jean Martin, iv, 269. Born at Paris, 1825; died at Paris, 1893. French physician and neurologist. Was Professor Pathological Anatomy, and afterward of Nervous Diseases in the Faculty of Medicine. He made extensive investigations in hypnotism and hypnotic suggestion for the treatment of hysteria and kindred disease.

Christy, Henry, iii, 104. Born at Kingston, England, 1810; died at La Palisse, France, 1865. English ethnologist. Made special study of the fossils discovered in the valley of the Vézère, France, and made valuable contributions to our knowledge of primitive man.

Clark, Alvan, iii, 66. Born at Ashfield, Mass., 1808; died at Cambridge, 1887. American opti-

BIOGRAPHICAL INDEX

cian. Son of a farmer, he taught himself engraving. Began to manufacture telescopes in 1844. Was the first to make achromatic lenses in the United States. The lenses of most of the great telescopes of recent times were ground at the establishment he founded for such purposes at Cambridge, Mass.

Clausius, Rudolf Julius Emanuel, vi, 115. Born at Koslin, Prussia, 1822; died at Bonn, 1888. German physicist who made a special study of thermo-dynamics.

Colding, Ludwig August, iii, 257. Born at Arnakke, Denmark, 1815. Danish engineer and meteorologist. Studied at Copenhagen and became professor there. Made special investigations of tropical cyclones.

Columbus, Christopher, ii, 50. Born near Genoa, Italy, cir. 1446; died at Valladolid, Spain, 1506. Italian explorer. Started his career in the wool-trade. Probably first went to sea about 1473, and lived in Lisbon until 1485, engaged in map-making, and seafaring, one voyage, 1477, taking him to Iceland. Convinced of the feasibility of reaching the spice-countries of Asia by a westward route, he sought financial assistance from Venice and Portugal without avail. Finally Queen Isabella became interested. An expedition was fitted out, and Columbus reached the West Indies (probably Watlings Island), October 12, 1492.

Cope, Professor Edward Drinker, iii, 113. Born at Philadelphia, 1840; died at Philadelphia, 1897. American naturalist. Studied medicine. Was Professor of Natural Science, Haverford College, afterward Professor of Geology, Uni-

KEY AND INDEX

versity of Pennsylvania. Made a special study of extinct vertebrates. He belonged to that school of evolutionists who believed that the variations caused by environment are inherited by offspring, and upholding these views, became involved in much controversy.

Copernicus, Nicolaus, ii, 54. Born at Thorn, Prussia, 1473; died at Frauenburg, 1543. German astronomer. Studied mathematics and other sciences at Cracow, afterward in Italy. Appointed Professor of Mathematics at Rome, 1500. 1505, returned to Germany, took holy orders and obtained canonry at Frauenburg. 1530, completed his great work "*De Revolutionibus Orbium*," which described the true system of the sun, stars and planets. This he did not publish until twelve years later, probably through fear of ecclesiastical censure.

Corvisart, Jean Nicolas de, iv, 199. Born at Drecourt, France, 1755; died at Paris, 1821. French physician. His father destined him for the law, but he ran away to Paris, and concealed himself in order to study medicine. 1786, became professor at La Charité Hospital, Paris. Later on Collège de France. Member Academy of Sciences. Was first physician to Napoleon I. Made valuable contributions to pathological anatomy regarding diseases of the heart.

Croll, Dr. James, iii, 197. Born at Whitefield, 1821; died in 1890. Scottish geologist. Had but little schooling, but made many valuable contributions of geological science, especially in regard to climatic changes during the glacial period, and their origin. Published theories as to origin of sun's heat and formation of stars

BIOGRAPHICAL INDEX

and nebulæ, which, though widely accepted, aroused much discussion. Was an officer of the Geological Survey of Scotland.

Crompton, Samuel, ix, 32. Born at Firwood, near Bolton, England, Dec. 3, 1753; died at Hall-in-the-Wood, near Bolton, June 26, 1827. An English mechanic and inventor. In 1779 he invented the "Mule," a spinning machine vastly superior to any machine then in use.

Crookes, Sir William, iii, 249, v, 103. Born at London, 1832. English physicist and chemist. Studied and taught at Royal College of Chemistry, Oxford, and Chester. Famous sanitary expert. His experiments with high vacua made the incandescent light possible. Discoverer of the element thallium, also the sodium amalgamation process for separating gold and silver from their ores. Devised new method of spectrum analysis for which the radiometer and otheoscope were invented.

Ctesbius, i, 243. Born at Alexandria; lived Third Century B.C. Greek mathematician, and tutor of Hero. Probably inventor of the force pump, and discoverer of the elastic force of air, with its possible application as motive power, all of which has been described by Hero.

Cunard, Sir Samuel, vii, 74. Born at Halifax, Nova Scotia, 1787; died at London, April 28, 1865. A civil engineer, founder of the Cunard Steamship Line. The first ship of this line, the "Britannia," crossed the ocean in 1840.

Curie, Professor Pierre, v, 100. Born at Paris, 1859; died at Paris, 1906. French physicist. Educated at Paris, became Professor of Physics at the Sorbonne, 1895. Noted for his researches

KEY AND INDEX

in radio-activity. In conjunction with his wife he discovered radium. The discovery was suggested by the fact that the Becquerel rays were analogous to the Röntgen rays, and that pitchblende possessed a high degree of radio-activity. By careful analysis M. and Mme. Curie extracted minute quantities of radium bromide in 1903, which feat seems likely to lead to extraordinary results in physics.

Curie, Madame Skaldowska, v, 100. Born at Warsaw, 1867. French scientist. Professor in the Faculty of Sciences, Paris. Wife of Prof. Pierre Curie, and associated with him in his researches.

Cuvier, Georges Baron de, iv, 159. Born at Montbéliard, France, 1769; died at Paris, 1832. French naturalist. Educated at Stuttgart for the Calvinistic ministry, in which faith he was strictly brought up. His great bent for natural history caused his father to abandon the plans for his future. Went to Paris and became Professor of Natural History successively at the Museum of Natural History, École Centrale des Panthéon and Collège de France. 1802, succeeded Mertrud at the Jardin des Plantes. Devoted his life to paleontology, systematic zoology, and comparative anatomy, of which last science he was the founder.

Daguerre, Louis J. M., iv, 70. Born at Cormeilles, France, 1789; died near Paris, 1851. French physicist and painter. Began life as scene painter and evolved the Diorama. Together with Nicéphore de Niépce in 1829, he began investigations in photography, and devised the means of photographing on a metallic

BIOGRAPHICAL INDEX

plate, from which all modern photography has developed. The daguerreotype was announced in 1839.

D'Alembert, Jean le Rond, iii, 15. Born at Paris, 1717; died at Paris, 1783. French mathematician and philosopher. Educated at the College Mazarin, and after trying law and medicine, devoted himself to mathematical science. Announced his famous principle of the equality of impressed and effective forces, 1743. Made many astronomical and mathematical solutions. 1751, with Diderot undertook editorship of the *Encyclopédie*. Withdrew in 1758. Had offers from foreign rulers which he did not accept.

Daniell, John Frederick, iii, 236. Born at London, 1790; died at London, 1845. English physicist who gave special attention to chemistry and meteorology. Professor of Chemistry, Kings College, London, 1831. Established, with Professor Brande, the "*Quarterly Journal of Science and Art*," 1816. Invented the hygrometer about 1820.

Dalton, John, iv, 40. Born at Eaglesfield, England, 1766; died at Manchester, 1844. English chemist. 1793 was made Professor of Mathematics and Physical Science at Manchester. He developed the atomic theory in chemistry, which revolutionized the science. In physics he experimented with the force of steam and electricity and expansive force of gases. Was held in the highest distinction and was the recipient of many honors. Was color-blind, and gave scientific description of this malady, which is often called Daltonism.

Dana, James Dwight, iii, 162. Born at Utica,

KEY AND INDEX

New York; died at New Haven, 1895. American geologist. Educated at Yale College. Appointed instructor U. S. Navy, afterward Professor Natural History at Yale (1855-1890). Member Wilkes exploring expedition (1838-1842), when he collected an immense amount of zoological material, on which he worked for thirteen years. Made valuable contributions to geology and mineralogy, and was honored by many scientific societies in Europe and America.

Darwin, Charles Robert, iii, 95, iv, 173. Born at Shrewsbury, England, Feb. 12, 1809; died at Down, Kent, April 19, 1882. English naturalist, the greatest of the Nineteenth Century. Educated Edinburgh and Cambridge, destined for the church, but his tendencies were strongly toward natural history. Went as naturalist on the "Beagle" expedition, 1831-36, and made many important contributions to zoology and geology. Announced his theory of natural selection with A. R. Wallace, who had arrived at the same idea independently, in 1858. Published "Origin of Species" in 1859. This revolutionized the whole study of zoology, from the standpoint of evolution. Darwin extended his general theory to man, and continued his studies tending to the demonstration and confirmation of his views.

Darwin, Erasmus, iv, 94. Born at Elston, England, 1731; died at Derby, 1802. English physician and naturalist, grandfather of Charles R. In his writings there is much that his grandson afterward confirmed. Lamarck and others who helped develop the theory of evolution owe much to Erasmus Darwin. He wrote in prose and in

BIOGRAPHICAL INDEX

didactic verse. His "Zoonomia" was so revolutionary in its ideas, that it is said that Paley wrote his "Natural Theology" to counteract its influence.

Davy, Sir Humphry, iv, 48. Born at Penzance, 1778; died at Geneva, 1829. English physicist. Was apprenticed to a surgeon, 1795, and began to study a wide range of subjects. At the age of nineteen he settled upon chemistry. Dr. Beddoes took him as his assistant at Bristol, and he soon discovered nitrous oxide (laughing gas). Was now appointed lecturer at the Royal Institution, London, and attracted brilliant audiences. 1802, made professor of chemistry there. Made extensive researches in agricultural chemistry. Most famous of all were his electrolytic experiments, which established Lavoisier's theories of the composition of bases. Davy decomposed potash and similar substances, and demonstrated the nature of chlorine and hydrochloric acid. In 1815 he investigated the nature of fire-damp, and invented the safety lamp. 1820, was elected President of the Royal Society. Later devised a method of preventing corrosion of copper bottoms of sea-going vessels. He died a member of nearly all the scientific institutions in the world.

Dawes, Rev. W. R., iii, 44. Born at London, 1799; died at Haddenham, 1868. English astronomer, practised medicine; also officiated for a time as minister. Had charge of several observatories in England. Discovered one of the rings of Saturn and many double stars.

De Bary, Heinrich Anton, iv, 125. Born at Frankfort-on-Main, 1831; died at Strasburg,

KEY AND INDEX

1888. German botanist. Studied at Heidelberg, Marburg, and Berlin. Professor at Freiburg, Halle, and Strasburg. He made a special study of fungi and was editor of the "Botanische Zeitung" from 1866 until his death.

De Forest, Lee, viii, 65. Born at Council Bluffs, Iowa, August 26, 1873. One of the pioneers of the development of wireless telegraphy and telephony in America. His system of wireless telegraphy was used extensively in the Russian-Japanese War.

Delambre, Jean Baptiste Joseph, iii, 16. Born at Amiens, 1749; died at Paris, 1822. French astronomer. Studied under Delisle and Lalande. Worked out tables of motion by Uranus after its discovery by Herschel (1781). He and Méchain superintended the measurement of the arc of the meridian (1792-99), for the base of the metric system. 1807, was made Professor of Astronomy in the Collège de France. Left numerous writings on astronomical subjects.

Delitzsch, Frederick, i, 96. Born at Erlangen, 1850; German assyriologist. Professor at Leipzig (1877), Breslau (1893), and Berlin (1899). Has written much on Assyriology and his works have attained a high degree of popularity.

Democedes, i, 172. Born at Crotona, Italy, middle Sixth Century B.C. Greek physician. Went to Greece, where he was taken prisoner by the Persians and carried to court, when he became physician to Darius I. Afterward he returned to Greece and to Crotona.

Democritus, i, 161. Born at Abdera, Thrace, cir. 470-460 B.C. Lived to a great age. Greek philosopher. Traveled extensively and was the

BIOGRAPHICAL INDEX

learned thinker of his age. Originated the atomic system, which assumed matter to be composed of indivisible atoms whose motion is derived entirely from themselves. From the combination made by the motion the whole of Nature is created. There is law in Nature, but no design. Upon his philosophy epicureanism was founded.

Descartes, René, ii, 193. Born at La Haye, 1596; died at Stockholm, 1650. French philosopher, the "father of modern philosophy." Educated by the Jesuits, he became dissatisfied with scholasticism, and resolved to free his mind from all he had learned in order to get at truth. Became a soldier and finally settled in Holland, where he wrote his books, taught, and became involved in many disputes with theologians. The principles of his systems were published in his "Discourse de la Méthode," 1637, in which he finds absolute truth only in those thoughts and ideas which are as distinct and clear as is his self-consciousness. With this system he revolutionized all methods of thought and logic: He also wrote a geometry which puts him among the leading mathematicians of his age. In 1649 he was called to Stockholm by Queen Christina and shortly after died there.

Desmoulins, Louis Antoine, iv, 249. Born at Rouen, 1794; died at Rouen, 1828. French naturalist and anatomist. Studied and practiced in Paris, where he made a special study of anatomy and the physiology of the nerve centers. He was a severe critic of Cuvier.

Dewar, Sir James, v, 39. Born at Kincardine-on-Forth, Scotland, 1842. Scottish chemist.

KEY AND INDEX

Educated Edinburgh, where for some years he was assistant to Lord Playfair, Professor of Chemistry. Afterward professor at Cambridge, and at Royal Institution. Made special studies of physiological action of light and liquefaction of gases.

Diodorus Siculus, i, 77. Born at Agyrium, Sicily, latter half First Century B.C. Greek historian. Set himself the task of writing a great history of the world, in preparing for which he traveled extensively in Europe and Asia, settling finally in Rome, where he lived many years. The preparation and writing of the work took not less than thirty years. It covers about 1,100 years down to the Conquest of Gaul by Cæsar.

Diogenes Laërtius, i, 121. Born at Laërte, Cilicia, about beginning Third Century A.D. Greek writer, whose principal work, "Lives of the Philosophers," in ten books, has preserved to us much knowledge of the history of Greek philosophy, although it is largely biographical, and gives little attention to the evolution of philosophic thought.

Dohrn, Dr. Anton, v, 121. Born at Stettin, 1840; died in 1908. German zoologist. Studied under Haeckel at Jena. Made special study of marine animals. 1870, founded the zoological station at Naples, the first and still the most important in existence.

Dove, Heinrich W., iii, 199. Born at Liegnitz, 1803; died at Berlin, 1879. German physicist and meteorologist. Educated Breslau and Berlin. Became professor University of Berlin, 1829. Director of the Royal Observatory. Made spe-

BIOGRAPHICAL INDEX

cial researches in climatology, meteorology, electricity, and polarized light.

Draper, Daniel, iii, 67. Born at New York, 1841. American meteorologist. Assisted his brother Henry in equipping his observatories, 1869. Made director New York Meteorological Observatory, and designed many self-recording instruments.

Draper, Dr. Henry, iii, 67. Born in Virginia, 1837; died in New York, 1882. American physician and scientist. Educated New York, Professor of Medicine, and afterward of Chemistry in New York University. Also interested in astronomy, built large telescope at Hastings-on-Hudson, and took up celestial photography with valuable results.

Draper, Dr. John W., iv, 70. Born near Liverpool, England, 1811; died at Hastings-on-Hudson, 1882. American chemist, physiologist, and writer. Educated London University. Came to America 1831. Studied University of Pennsylvania. Professor in Hampden Sidney Coll, Va., 1836. 1839, came to New York and helped found Medical School, New York University, where he was Professor of Chemistry, afterward (1850), of Physiology. Made valuable contributions to physical chemistry, especially in chemical action of light, and spectrum analysis, and he greatly improved the daguerreotype process.

Dubois-Reymond, Emil, iv, 262. Born at Berlin, 1818; died at Berlin, 1896. German physiologist. Educated at Berlin for the ministry; finally turned to chemistry and physics; later to medicine. 1858, became Professor of Physiology,

KEY AND INDEX

University of Berlin; 1867, perpetual secretary Berlin Academy of Sciences. He made a special study of animal electricity, and laid the foundation for all our knowledge of this subject. Invented the method for reading table messages by light deflected from a mirror attached to the needle of a galvanometer.

Dufay, Charles François de Cisternay, ii, 267. Born at Paris, 1698; died at Paris, 1739. French chemist. Destined for the army, he paid more attention to science, and soon abandoned military service to devote himself to chemistry. 1733, was made member of the Academy of Sciences, and pursued anatomy, botany, astronomy, mathematics, and mechanics as well as chemistry. Noted for his researches in the phenomena of phosphorescence and the properties of caustic soda. Made many surprising discoveries in electricity. Made many experiments in the double refraction of crystals. Through his efforts the Jardin des Plantes was greatly improved and developed.

Dujardin, Felix, iv, 124. Born at Tours, 1801; died at Rennes, 1860. French zoologist. Studied Tours and Paris. Became Professor of Zoology in the Faculté de Rennes. Made a special study of worms and insects.

Dumas, Jean Baptiste, iv, 128. Born at Alais, 1800; died at Cannes, 1884. French chemist. Was apprenticed to an apothecary in Geneva. Went to Paris and studied chemistry. Professor of Chemistry in the Athenæum, later at the Sorbonne. Made a specialty of organic chemistry; and made many valuable researches for the determination of atomic weights. Also occupied

BIOGRAPHICAL INDEX

several political positions. Was Minister of Agriculture and Commerce, 1840-1851.

Edison, Thomas A., vi, 228; vii, 182. Born at Milan, Ohio, Feb. 11, 1847. Inventor of the phonograph, the incandescent lamp and light system, a system of wireless telegraphy, and more than seven hundred other inventions, or improvements on mechanical devices.

Empedocles, i, 114. Born at Agrigentum, Sicily, cir. 490 B.C.; died cir. 430 B.C. Greek philosopher and physician. In his philosophical teachings he assumed four elements, earth, air, fire, and water, which existed together immovable in the perfect primitive world by means of an uniting cause "Friendship," until the external separating cause "Strife" entered into the world and acting on the elements gave rise to all individual and contrary phenomena.

Erasistratus, i, 194. Born at Julis, Ceos, cir. 330 B.C. Greek physician. Became body physician at Court of King Selectus Nicator of Syria. Went to live in Pamos and gave himself up to study of anatomy. He was the first to perceive the difference between the sensory and motor nerves, and traced both to the brain. He seemed to have some idea of the circulation of the blood, and of the functions of the veins and arteries.

Eratosthenes, i, 225. Born at Cyrene, cir. 275 B.C.; died at Alexandria, 195 B.C. Greek astronomer and geometer, pupil of Lysanias and Callimachus. Went to Athens. 240, succeeded Callimachus as head of the Alexandrian Library. Became blind and voluntarily starved himself to death. Attempted to measure the obliquity

KEY AND INDEX

of ecliptic and came within 23° of being correct. Computed the circumference of the earth to be 250,000 stadia. His geography in three books is the first scientific treatise on the subject ever attempted.

Ericsson, John, vi, 134. Born at Wermland, Sweden; died at New York, March 8, 1889. Famous Swedish-American engineer and inventor. He is best known as the inventor of the caloric engine (1833) and the turreted iron-clad Monitor (1862). He applied the screw to steamships, invented the torpedo-boat destroyer, and a type of solar engine.

Erman, Professor Adolf, i, 28. Born at Berlin, 1854. German Egyptologist. Educated Berlin and Leipsic. 1885, director of Egyptian Department, Royal Museum, Berlin. 1892, Professor of Egyptology, University of Berlin. He has put the study of the ancient Egyptian languages upon a scientific basis through a thorough study of its grammar.

Euclid, i, 193. Lived at Alexandria in Third and Fourth Centuries B.C. Greek geometer, the most famous of antiquity. He worked out a large number of the problems of elementary geometry.

Euler, Leonhard, iii, 17. Born at Basel, 1707; died at St. Petersburg, 1783. Swiss mathematician. Educated at Basel, receiving master's degree at age of sixteen. Studied mathematics, theology, Oriental languages, and medicine. 1727, went to St. Petersburg on invitation of Catherine I. Became Professor Higher Mathematics, 1733. 1740, called by Frederick the Great to Berlin to take Chair of Mathematics.

BIOGRAPHICAL INDEX

in Academy of Science. 1766, recalled to St. Petersburg and died there. Contributed voluminously to the science of mathematics.

Eustachio, Bartolommeo, ii, 165. Born at San Severino, early in Sixteenth Century; died in 1574. Italian anatomist. 1562, became Professor of Medicine in the Collegio della Sapienza, Rome. Discoverer of the eustachian tube in the ear, and the rudimentary valve of the heart. He first described the thoracic duct, and perhaps also first noticed the stapes. He materially increased knowledge in regard to the teeth and the kidneys. He was one of the founders of modern anatomy.

Evans, Oliver, vi, 113. Born at Newport, Del., 1755; died at New York, 1819. American mechanician and inventor. Made valuable improvements in mill machinery. Said to have designed (1795) first high-pressure engine.

Falconer, Hugh, iii, 99. Born at Forres, Scotland, 1808; died at London, 1865. Scottish botanist and paleontologist. Educated at Aberdeen and studied medicine at Edinburgh. Spent most of his life in India, where he went in 1829. On his recommendation tea culture was introduced into India. Discovered the asafœtida plant. Found many important vertebrate fossils in Northern India. Was superintendent of the botanical garden at Saharanpur, and in 1847 was made superintendent of Calcutta Botanical Garden, and professor of botany in the medical college there.

Fallopious, Gabriello, ii, 166. Born at Moderna, Italy, 1523; died at Padua, Oct. 9, 1562. Celebrated Italian anatomist. Professor of anatomy

KEY AND INDEX

at Ferrara, Pisa and Padua. Made several important discoveries in the anatomy of the ear, the fallopian tube being named for him. In the controversy over the question as to whether there are valves in the veins, Fallopius declared that he was unable to find such valves. The fact of their existence was established by his contemporaries.

Faraday, Michael, iii, 241. Born near London, 1791; died at Hampton Court, 1867. English chemist and physicist. Apprenticed to a bookbinder, he gave all his spare time to science, especially experiments in electricity. Davy became interested in him and took him as assistant. He became one of the most brilliant experimentalists science has ever known. Liquified certain gases by pressure. Discovered the revolution of a magnetic needle due to an electric current. Discovered action of currents on each other and laid the foundation of magneto electricity. Valuable researches in electrolysis. Discovered benzol, the basis of aniline dyes.

Fechner, Gustav, iv, 263. Born at Gross-Sährchen, 1801; died at Leipsic, 1887. German physicist and philosopher. He founded modern psychology, and psycho-physics. Educated, Leipsic for a physician, but turned to physics. Researches in electricity and physiological optics. After 1845 devoted himself to philosophy. Advocated mentality of a low order in the plant world. Worked out a comprehensive system of metaphysics. In his most famous work, "Psychophysik," he developed the psychophysical measurement methods which are still in use to-day.

BIOGRAPHICAL INDEX

Ferrel, Professor William, iii, 200. Born in Pennsylvania, 1817; died at Maywood, Kansas, 1891. American meteorologist. Made important contributions to the science. Invented the maxima- and minima-tide-predicting machine, which has been in use for many years in the Government Coast Surveys.

Ferrier, Dr. David, iv, 273. Born at Aberdeen, 1843. Scottish neurologist. Educated, Scotland and at Heidelberg. 1872, Professor of Neuro-pathology, Kings College, London. Has greatly increased our knowledge of the functions and diseases of the brain.

Field, Cyrus W., viii, 30. Born at Stockbridge, Mass., Nov. 30, 1819; died at New York, July 12, 1892. He founded the Atlantic Telegraph Company which laid the first successful Transatlantic cable.

Fitch, John, vii, 63. Born at Windsor, Conn., Jan. 21, 1743; died (committed suicide), Bardstow, Ky., July 2, 1798. American inventor. He built various types of steamboats of his own inventing, the first in 1787. These boats were of no practical value, but marked steps in the advancement toward Fulton's crowning achievement.

Fizeau, Hippolyto Louis, viii, 228. Born at Paris, 1819; died at Nanteuil, 1896. French physicist. 1839, began researches to make daguerreotypes permanent. Devised apparatus for measuring velocity of light (1856), and won prize of 10,000 francs.

Flourens, Marie Jean Pierre, iv, 270. Born at Maureilhan, Hérault, 1794; died at Montgeron, 1867. French physiologist. Educated at Mont-

KEY AND INDEX

pellier. Assistant and successor to Cuvier, as Professor of Natural History in the Jardin du Roi. 1835, became professor in the College de France. A voluminous writer on comparative anatomy and physiology, natural history, etc. Wrote a famous work on the formation of the bones. Made a peer by Louis Philippe, 1846.

Forbes, James David, iii, 275. Born at Edinburgh, 1809; died at Clifton, England, 1868. Scottish physicist and geologist. Educated, Edinburgh, for the law, but his natural bent led him to physics. 1833, became Professor of Physics, Edinburgh University. Made special study of thermal radiations which resulted in the discovery of the polarization of heat. Made important contributions to our knowledge of the origin and movement of glaciers.

Foster, Sir Michael, v, 17. Born at Huntingdon, Eng., 1836. English physiologist. Educated University College, London. Taught there and at Cambridge. Became Professor of Physiology, Cambridge University, 1883. 1900, member of Parliament for London University.

Foucault, Jean Bernard. Born at Paris, 1819; died at Paris, 1868. French physicist. Educated for the medical profession. 1854, appointed Physicist, Paris Observatory. First direct measurements of velocity of light were due to him and Fizeau. Showed that velocity of light in air was greater than in water. Invented polarizing prism, and an apparatus for regulating electric light. Made many researches in electricity. The Foucault currents were named after him.

Fourneyron, Benôit, vi, 72. Born at St.

BIOGRAPHICAL INDEX

Etienne, France, Oct. 31, 1802; died at Paris, July, 1867. French engineer who improved the construction of turbine water-wheels.

Franklin, Benjamin, ii, 286. Born at Boston, 1706; died at Philadelphia, 1790. American scientist and statesman. Apprenticed to a printer he soon went to Philadelphia and began a life of great public activity, rendering great service to his country in many ways. He held political offices, spent much time in Europe on behalf of the colonies, and later as an emissary of the new American nation to obtain help from France. In 1731 he started the Philadelphia Library. In 1744, founded the American Philosophic Society. Invented the Franklin stove, made many civic improvements, and made valuable investigations in electricity, demonstrating the electrical nature of lightning (1752).

Frauenhofer, Joseph von, iii, 60.. Born at Straubing, 1787; died at Munich, 1826. German physicist. Began life as a working optician and became head of a firm of opticians. Invented means of obtaining large piece of optical glass free from imperfections for lenses and prisms. Many inventions to perfect making of lenses, prisms, etc. Discovered the dark lines in the spectrum called by his name. Measured the wave lengths of sodium light by means of diffraction grating.

Fresnel, Augustin Jean, iii, 226. Born at Broglie, 1788; died near Paris, 1827. French physicist. Educated Caen and Paris. Became Government engineer. Independently of Young he demonstrated the falsity of the Newtonian theory of light, and advocated the undulatory the-

KEY AND INDEX

ory, which with Arago's assistance he afterward proved. Made investigations in polarized light, and applied improved and scientific methods to the making of lighthouse lenses.

Fulton, Robert, vii, 70; vii, 98. Born at Little Britain, Pa., 1765; died at New York, Feb. 24, 1815. American inventor, whose invention of the steamer "Clermont" opened the era of steam navigation. He began life as a portrait- and landscape-painter, but soon abandoned art to devote his time to engineering. While residing in France in the closing years of the Eighteenth Century, he invented torpedo boats and submarine boats. There, also, he built a steamboat which made a successful trip on the Seine in 1803.

Galen (Claudius Galenus), i, 272. Born in Pergamum, 130; died in Sicily, 201. Greek physician. Studied in Pergamum, Smyrna, Corinth and Alexandria. Went to Rome, where he attended the Emperor. Wrote many treatises on all branches of medicine, of which those on anatomy and physiology are most valuable. He bases his practice on two principles: First, that disease must be overcome by something contrary to disease itself. Second, that nature is preserved by that which has relation to nature.

Galilei, Galileo, ii, 76. Born at Pisa, Feb. 14, 1564; died at Arcetri, Jan. 8, 1642. • Famous Italian physicist and astronomer. Discovered the ischronism of the pendulum in 1583, and the hydrostatic balance in 1586. Constructed a thermometer in 1597. Professor of mathematics at Padua, 1592 to 1610. While at Padua he made many inventions, the most important being the

BIOGRAPHICAL INDEX

refracting telescope, with which he discovered the satellites of Jupiter (1610), phases of Venus, sun-spots, etc. In his work on the sun-spots he advocated the Copernican theory, and was denounced as a heretic. Was tried and compelled to recant his views. Imprisoned, but soon released and retired to Florence.

Gall, Franz Joseph, iv, 248. Born at Tiefenbronn, 1758; died at Montrouge, 1828. German physician and phrenologist. Studied Strasburg and Vienna, practiced in latter city. 1796, began to lecture on structure and function of brain, and for his views the Austrian Government compelled him to leave Vienna, 1802. Settled finally in Paris, practiced and lectured. Here he continued to lay the foundations of phrenology, in spite of charges of materialism and fatalism constantly brought against his system.

Galton, Francis. Born at Birmingham, 1822. English anthropologist and meteorologist. Educated Birmingham, London, and Cambridge. 1850, started to explore in Africa and discovered the Orampo race. Promulgated the theory of anti-cyclones (1863), which is the foundation of weather forecasts. Of late years his studies have been mostly in anthropology and biology. His views on heredity have been widely discussed. He was the first to apply statistics to anthropology and invented the means of taking composite photographs. Has devised various measuring apparatuses for purposes of psychology.

Galvani, Luigi, iii, 229. Born at Bologna, 1737; died at Bologna, 1798. Italian physician and anatomist. Educated for the priesthood but

KEY AND INDEX

turned to medicine. Was Professor of Anatomy at Bologna. By an accident he discovered the existence of the galvanic current, which led to the invention of the voltaic cell and all that has developed from it.

Gauss, Karl Friedrich. Born at Brunswick, 1777; died at Göttingen, 1855. German mathematician, one of the most brilliant of modern times. Born in poverty, but was educated at Göttingen. Invented a method of calculating positions of heavenly bodies in order to rediscover the lost planet Ceres. Devoted latter part of life to geodesy and the mathematical theory of electricity. Developed the theory of least squares.

Gay-Lussac, Joseph Louis, iv, 41. Born at Saint-Léonard le Noblat, 1778; died at Paris, 1850. French chemist and physicist. Studied at Paris. Became assistant to Berthollet at the Government chemical works. Made balloon ascent to ascertain whether magnetic force existed above the earth. With Humboldt he announced the exact composition of water (1804), which led to the discovery by Gay-Lussac in 1808 of the important law of volumes. 1809, became Professor of Chemistry at École Polytechnique. Discovered a better way than electrolysis for producing potassium.

Geber, ii, 20. Died about 1776. An Arabian chemist. He discovered sulphuric, nitric, and nitromuriatic acids, thus greatly increasing the possibilities of chemical experiment. He is credited with writing about five hundred works. Of these "Testamentum," "De Inventionibus Vintatis," "Liber Fornacum," "Summa Perfectionis," "De

BIOGRAPHICAL INDEX

Investigatione Perfectionis," and "Liber Investigationis," have appeared in print.

Gilbert, William, ii, III. Born at Colchester, England, 1540; died Nov. 30, 1603. English physician and natural philosopher. Physician in ordinary to Queen Elizabeth and James I. President of the College of Physicians in 1600. With the doubtful exception of Bacon, Gilbert was the most distinguished man of science during the reign of Queen Elizabeth. His studies of electricity and magnetism led Priestly to call him "the father of modern electricity." He was the first to discover that the earth is a magnet, and explained the dipping of the needle by the magnetic poles. He also gave the name of "pole" to the extremities of the magnetic needle, and was first to make use of the terms "electric force" and "electric attractions." He was first to distinguish between magnetism and electricity, and made the first electrical instrument ever constructed. He made also the first electrical indicating device. The method of magnetising iron first introduced by him is in common use to-day.

Gill, Sir David, iii, 67. Born at Aberdeen, Scotland, June 12, 1843. Scottish astronomer and Astronomer Royal at the Cape of Good Hope from 1879. He made five photographs of a comet, and the flecks of starlight on his plates first suggested the possibilities of this method in charting the heavens. His observations of the transit of Venus in 1882 were invaluable in the determination of the distance of the sun from the earth.

Gladstone, Professor J. H., iv, 68. Born at

KEY AND INDEX

London, 1827; died October, 1902. English scientist. Professor of Chemistry at the Royal Institution, 1874-77. Published "Life of Michael Faraday," and "Chemistry of Secondary Batteries."

Goethe, Johann Wolfgang von, iv, 140. Born at Frankfort-on-the-Main, Aug. 28, 1749; died at Weimar, March 22, 1832. German poet, dramatist, and scientist. In 1790 published the "Metamorphoses of Plants," in which he advanced the novel doctrine that all parts of the flower are modified or metamorphosed leaves. A little later he advanced the doctrine that the vertebrate skull is essentially a modified and developed vertebra. This doctrine of metamorphosis of parts soon came to be regarded as of fundamental importance.

Goodyear, Charles, ix, 113. Born at New Haven, Conn., Dec. 29, 1800; died at New York, July 1, 1860. American manufacturer. He discovered the process of treating india-rubber known as "vulcanization," a process upon which the usefulness of rubber is largely dependent. He also invented a machine for the sewing of soles, known as a "turn-sole machine," which was of great commercial importance.

Gordon, Andrew, ii, 279. Born at Coforach, Forfarshire, June 15, 1712; died Aug. 22, 1751. A Scotch Benedictine monk and physicist, noted for his experiments in frictional electricity. He was first to invent an electric bell which would ring automatically, and a "motor," in the form of a wheel which was revolved by the action of electricity. He demonstrated the force of the electric current by killing birds and small ani-

BIOGRAPHICAL INDEX

mals at a distance of two hundred ells, the current being conveyed by small wires.

Gray, Asa, iv, 175. Born at Paris, New York, Nov. 18, 1810; died at Cambridge, Mass., Jan. 30, 1888. American botanist. Professor of Natural History at Harvard, 1842-88. Championed Darwin's theory of evolution, and wrote "Darwiniana" in 1876. Some of his best-known works are, "Elements of Botany," "Flora of North America," "How Plants Grow," "Field, Forest and Garden Botany," and "Manual of Botany of the United States."

Gray, Prof. Elisha, vii, 85; viii, 26. Born at Barnesville, Ohio, Aug. 3, 1835; died at Newtonville, Mass., Jan. 20, 1901. American inventor. Remembered particularly for his inventions relating to telegraphy and the telephone. He filed specifications of a telephone in the United States Patent Office only a few hours later than Dr. Graham Bell, whose invention opened the era of telephonic communication.

Gray, Stephen, ii, 262. Died February 25, 1736. A pensioner of the Charter House in London. In his experiments with electricity he discovered two of the most important properties of electricity—that it can be conducted and insulated.

Guericke, Otto von, ii, 213. Born at Magdeburg, Prussia, Nov. 20, 1602; died at Hamburg, May 11, 1686. German natural philosopher. He invented the first electrical machine, and discovered electrical attraction and repulsion. He invented the air pump and the air balance, and demonstrated the pressure of the atmosphere

KEY AND INDEX

with the "Magdeburg hemispheres," see Vol. ii, 211.

Guy of Chaulic, ii, 38. Born about 1300. Famous French surgeon. Introduced the treatment for broken limbs by suspension in a cradle, and the method of making "traction" to prevent deformity by shortening of the member—a method still in use. He was one of the first physicians to advocate the use of glasses in certain eye disorders.

Haeckel, Ernst Heinrich, v, 144. Born at Potsdam, Prussia, Feb. 16, 1834. Distinguished German naturalist. One of the leading advocates of the biological theory of evolution. For a time he practiced medicine in Berlin, but in 1861 he left the field of medicine to become a privat-docent in Jena. In 1865 he was appointed to a chair of zoology which was specially established for him. He has written many monographs of systematic and descriptive nature, these works alone "constituting a good life's work." In addition he has written several other works, some of them of a popular nature. In 1866 he published his "General Morphology," and about two years later he rewrote the same work in a more popular style, published as the "Natural History of Creation." In his book "Die Welt-räthsel," published in English as "The Riddle of the Universe," he applies the doctrine of evolution to the problems of philosophy and religion carried to its logical conclusion.

Hahnemann, Christian Samuel Friedrich von, iv, 189. Born at Meissen, Saxony, April 10, 1755; died at Paris, July 2, 1843. German physician, founder of homeopathy. His new system

BIOGRAPHICAL INDEX

of medicine was expounded about 1796, and later elaborated in his work "Organon der Rationellen Heilkunde."

Hales, Stephen, ii, 298. Born at Bekesbourne, Kent, Sept. 7, 1677; died at Teldington, near London, Jan. 4, 1761. English clergyman, inventor, and physiologist. His most important invention was a "ventilator" for introducing fresh air into jails, mines, ships' holds, etc. Only four deaths in four years occurred in the Savoy Prison after this ventilator was introduced there, whereas the mortality previous to that time had been from 50 to 100 per annum. Hales' work, "Vegetable Statics" (1727), on the subject of vegetable physiology was the first important publication on the subject.

Hall, Marshall, M.D., F.R.S.L., iv, 251. Born at Basford, Notts, Feb. 18, 1790; died at Brighton, England, Aug. 11, 1857. English physician, the discoverer of the phenomena known as reflex action. This discovery marked an epoch in physiology. The most popular of Hall's discoveries was his "ready method" for resuscitating in drowning, by which innumerable lives have been saved.

Haller, Albrecht von, iv, 73. Born at Bern, Switzerland, Oct. 16, 1708; died at Bern, Dec. 17, 1777. Anatomist, physiologist, botanist, and poet. A sickly, but precocious child, he read and expounded the Bible at the age of four; and before ten years of age had "sketched a Chaldee grammar, prepared a Greek and a Hebrew vocabulary, and compiled a collection of two thousand biographies of famous men and women." His greatest contribution to medicine was his

KEY AND INDEX

“doctrine of irritability,” for which he has been called “the father of modern nervous physiology.”

Halley, Edmund, iii, 7. Born at Haggerston, England, Oct. 29, 1659; died at Greenwich, Kent, 1742. English astronomer and mathematician. Before he was nineteen he had published a work which supplied a defect in Kepler’s theory of planetary motion. At the age of twenty he established the certainty of the motion of the sun round its own axis by his observation of a sun spot. In 1720 he was appointed Astronomer Royal at Greenwich. His popular fame rests on his observation of the comet named for him, and whose orbit is of such size that the comet makes its appearance only once in every 76 or 77 years. In all this comet has appeared 26 times during the historic period of which we have any record. Its first appearance was in the year 11 B.C., its last in 1910.

Hargreaves, James, ix, 16. Born at Blackburn, Lancashire, England; died at Nottingham, April, 1778. English mechanic and inventor. His invention of the spinning-jenny, patented in 1770, revolutionized the spinning industry.

Harrison, John, vii, 25. Born at Yorkshire, England, March 31, 1698; died at London, March 24, 1776. English mechanician and inventor. He invented the compensating pendulum, by the use of which clocks could be made accurate time-keepers regardless of surrounding temperature. He also invented the chronometer, and was finally awarded the prize of twenty thousand pounds offered by the British Government for such a timepiece.

BIOGRAPHICAL INDEX

Harvey, William, ii, 169. Born at Folkestone, England, April, 1578; died at Hempstead, Essex, June 3, 1657. An English physician, famous as the discoverer of the circulation of the blood. His experiments to demonstrate his theory were made upon serpents, and his demonstrations were such that his conclusions were accepted almost immediately by scientists all over the civilized world.

Hauksbee, Francis, ii, 259. English physicist, one of the early experimenters with electricity. Through experiments with a whirling globe from which the air had been exhausted, and with a barometer and rubbed glass rods he produced a glow which he found to be electrical. He also discovered the important property of electricity known as "induction" by revolving two cylinders placed about an inch apart.

Helmholtz, Hermann Ludwig Ferdinand von, iii, 280. Born at Potsdam, Aug. 31, 1821; died at Berlin, Sept. 8, 1894. German physiologist and physicist. At the age of twenty-two he was military physician at Potsdam. Later was Professor of Anatomy and Physiology at Bonn, Professor of Physiology at Heidelberg, and Professor of Physics at Berlin. In 1851 he invented the ophthalmoscope—an instrument invaluable to oculists for examining the internal structures of the eye. He formulated an electro-magnetic theory of light, which was shown to be correct by the experiments and discoveries of his pupil, Heinrich Hertz.

Henderson, Thomas, iii, 61. Astronomer Royal of Scotland. He was one of the first astronomers to detect and measure the parallax of

KEY AND INDEX

a star, in point of time his observations preceding Bessel's, although Bessel's were much more numerous. These observations solved the problem of star distance.

Henry, Joseph, iii, 239; vi, 175. Born at Albany, N. Y., Dec. 17, 1797; died at Washington, D.C., May 13, 1878. An American physicist, and secretary of the Smithsonian Institution. Noted for his experiments in electro-magnetism. He constructed electro-magnets of greater power than any hitherto known, and was the first to adopt insulated or silk-covered wire for the magnetic coil. He invented a magnetic bell for signaling, which is considered the first example of a true magnetic telegraph. Foreign estimates place him in the foremost rank of American physicists of the Nineteenth Century.

Heraclides, i, 196. A Greek physician, who decried the study of anatomy, depending entirely upon the use of drugs for curing diseases. He is said to be the first physician to use opium in painful affections.

Hero, i, 242. Alexandrian mathematician of the Third Century, B.C. He wrote several works, only one of which, "Pneumatics," has been preserved. In his studies of gas, liquids and solids, he shows a fairly clear conception of the "atomic" nature of matter. He describes also the mechanism of various mechanical toys and devices, among them a ball rotated by the action of steam.

Herodotus, i, 103. Born at Halicarnassus, Asia Minor, about 484 B.C.; died at Thurii, Italy, about 424 B.C. Celebrated Greek historian, called "the Father of History." In his

BIOGRAPHICAL INDEX

writings he tells of an eclipse which occurred in 585 B.C. (modern astronomers reckon the exact date to be May 25th), which had been foretold by Thales. This is the first recorded instance of a predicted eclipse.

Herophilus, i, 194. Lived about 300 B.C. Greek anatomist and physician. With Erasistratus, the earliest scientific investigator of the mechanism of the human body. Discovered that the nerve trunks have their origin in the brain and spinal cord, and are of two different kinds, motor and sensory. Also made fairly accurate study of the anatomy of the eye.

Herschel, Sir John, iii, 58; iv, III. Born near Windsor, March 7, 1792; died at Collingwood, Kent, May 11, 1871. English astronomer; son of Sir William Herschel. Made important observations of double stars. In 2,299 telescopic fields he counted 68,948 stars. In his studies of the milky way he estimated that the stars visible in a reflecting telescope of 18 inches aperture amounted to over five million.

Herschel, Sir William, iii, 20. Born at Hanover, Prussia, Nov. 15, 1738; died at Slough, England, Aug. 25, 1822. Celebrated English astronomer of German birth. Deserted from German army and went to England in 1757. Gained considerable success as violinist, organist, and teacher of music. Was self-instructed in mathematics and astronomy, and constructed his own telescopes. He discovered the planet Uranus in 1781, and the following year was made Court astronomer. With his forty-foot reflecting telescope he determined definitely that the stars are suns, not merely "points of light" as had

KEY AND INDEX

been believed by many, even in the Eighteenth Century, and made pioneer observations in nearly every branch of astronomy.

Hertz, Heinrich Rudolf, iii, 247. Born at Hamburg, Germany, Feb. 22, 1857; died at Bonn, Jan. 1, 1894. German physicist. In 1883 he began studies in Maxwell's electro-magnetic theory, and finally established the fact that "ordinary light consists of electrical vibrations in an all-pervading ether, which possesses the properties of an insulator and of a magnetic medium." The results of his observations have been turned to practical account in the wireless telegraph and telephone systems of the present time.

Hevelius, Johannes, iii, 3. Born at Dantzic, Prussia, Jan. 28, 1611; died at Dantzic, Jan. 28, 1687. A Polish astronomer. His fame as an astronomer rests largely on his accurate description of the face and the spots of the moon. He was a friend and coworker of Edmund Halley, the English astronomer.

Hewitt, Peter Cooper, vi, 236. Born at New York. American electrician. Inventor of the mercury-vapor electric light, in which mercury vapor takes the place of the carbon or metal filament of the incandescent lamp.

Hildanes, Fabricius, ii, 183. Born in 1560; died in 1639. A German physician and surgeon. He invented many useful surgical instruments, several of them for locating and removing bullets. Contrary to the teachings of his time he was an ardent advocate of the study of anatomy. He was first to use a magnet for removing particles of metal from the eye.

Hinrichs, Professor Gustav, iv, 67. An Amer-

BIOGRAPHICAL INDEX

ican chemist. One of the first to conceive the so-called "law of octaves," which later was explicated fully by Mendelèeff under the title of "the periodic law."

Hipparchus, i, 233. Born at Nicæa, in Bithynia, 160 B.C. A Greek astronomer called "the lover of truth," one of the founders of scientific astronomy. He discovered the precession of the equinoxes, some of the inequalities of the moon's motion, and the eccentricity of the solar orbit.

Hippocrates, i, 170. Born at Island of Cos, about 460 B.C.; died at Larissa, Thessaly, about 377 B.C. A Greek physician, termed the "Father of Medicine." His most revolutionary step was divorcing the supernatural from the natural, and establishing the fact that disease is due to natural causes. This led to closer and systematic observation of cases, and written observations—"clinical histories" as they are called. Some of the surgical procedures described by him are followed, with slight modifications, by modern surgeons.

Hoffman, Friedrich, iv, 184. Born at Halle, Prussia, Feb. 19, 1660; died at Halle, Nov. 12, 1742. A celebrated German physician. He arranged the doctrines of Boerhaave into a "system" which considered force inherent in matter, expressed as mechanical movements, and determined by mass, number, and weight. He introduced several new remedies, one of them "Hoffman's anodyne" (spirits of ether), which is still in use.

Holland, John P., vii, 105. Born in 1841. American inventor. Began building submarine boats in 1875, and in 1900 had so perfected them

KEY AND INDEX

that one was accepted by the United States Government. Since that time he has added improvements to his boats, a fleet of which are now in commission in the United States service.

Holland, Philemon, i, 77. Born at Chelmsford, England, 1552; died at Coventry, Feb. 9, 1637. English writer and translator. He translated Pliny's "Natural History" in 1601.

Honain ben Isaac, ii, 24. Lived about 809-873, A.D. An Arabian physician. He was a Christian Arab, who followed the medical teachings of Galen. He was a great translator, and one of the greatest philosophers of the Ninth Century.

Hooke, Robert, ii, 215. Born at Isle of Wight, England, July 18, 1635; died at London, March 3, 1703. English mathematician and natural philosopher. Inventor of many ingenious and useful devices, among them the balance-spring for regulating watches. He originated the idea of making use of the pendulum in measuring gravity, and first proposed the wave theory of light.

Hooker, Sir Joseph Dalton, iv, 171. Born at Halesworth, Suffolk, June 30, 1817. English botanist. With Lyell he first induced Darwin to make public his work on the theory of evolution. He was director of the Kew Gardens for twenty years, president of the Royal Society in 1873, and president of the British Association in 1868.

Howard, Luke, iii, 182. British scientist. Died early in the Nineteenth Century. In 1803 he published in the "Philosophical Magazine," a paper on clouds in which he gave names that

BIOGRAPHICAL INDEX

were afterward universally adopted. He held that clouds are composed of vapor that has previously risen from the earth.

Howe, Elias, ix, 93. Born at Spencer, Mass., July 9, 1819; died at Brooklyn, N. Y., Oct. 3, 1867. American inventor. He invented a sewing-machine in 1845, which is considered the direct ancestor of all modern sewing-machines. It used an eye-pointed needle, and a shuttle, such as sewing-machines use at present.

Huggins, Sir William. Born at London, Feb. 17, 1824; died in May, 1910. English astronomer. He was a pioneer in utilizing spectroscopy and photography together. In 1864 he discovered that the planetary nebula in Draco consists of luminous gas. In 1868, through use of the spectroscope, he proved the existence of carbon in comets. His name is closely associated with most recent advances in spectrum analysis.

Humboldt, Alexander von, iii, 192. Born at Berlin, Sept. 14, 1769; died at Berlin, May 6, 1859. Celebrated German scientist and author. In a paper on isothermal lines and the distribution of heat on the earth he laid the foundation for a science of comparative climatology. He made extensive journeys in South America, Mexico, Siberia and the Caspian Sea region for scientific observation. His "Kosmos" published in 1845-58 is perhaps the greatest of his books.

Hunter, John, iv, 78. Born at Long Calderwood, Scotland, Feb. 13, 1728; died at London, Oct. 16, 1793. British surgeon, anatomist and physiologist. First to discover the system of vessels known as lymphatics, although the function of these vessels was suggested by his

KEY AND INDEX

brother, William Hunter. His studies of tendons laid the foundation for the operation for the cure of club feet. His experiments to determine the blood-supply for the growing antler of a deer led to the discovery of the "collateral circulation of the blood"—one of the most important discoveries in surgery. This led directly to his invention of the "Hunterian" operation for aneurism, an operation still in use, and which has made the name of Hunter immortal in the annals of surgery.

Hunter, William, iv, 76. Born at Long Calderwood, Scotland, May 23, 1718; died at London, March 30, 1783. British physician, anatomist and physiologist. The first great teacher of anatomy in England. He discovered the function of the lymphatics, and his writings on the structure of the synovial membranes, in 1743, anticipated Bichat's writing on the same theme by sixty years. He established a museum which is now the property of the University of Glasgow.

Hutton, James, iii, 178. Born at Edinburgh, June 3, 1726; died March 26, 1797. Scottish geologist. One of the founders of geological science. In his "Theory of the Earth," he expounded the doctrine that the present rocks of the earth's surface have been formed out of the waste of older rocks; that these materials have been laid down under the sea and consolidated by great pressure; that the expansive power of subterranean heat afterward upheaved them, and that masses of molten rock were injected into the gaps of the disrupted strata.

Huxley, Thomas Henry, iii, 112; iv, 174. Born

BIOGRAPHICAL INDEX

at Ealing, England, May 4, 1825; died at Eastbourne, June 29, 1895. English biologist. Foremost English champion of Darwin's theory of evolution, his active interest in the subject being largely responsible for the early acceptance of Darwin's conception.

Huygens, Christian, ii, 218. Born at The Hague, April 14, 1629; died there June 8, 1695. A celebrated mathematician, physicist, and astronomer. He was the inventor of the pendulum clock. With his brothers he constructed a telescope with which he discovered a hitherto unknown satellite of Saturn. Later he adapted the micrometer to the telescope, this being a mechanical device upon which the nice determination of minutes depends. One of his many interesting papers sent to the Royal Society was his "Rules Concerning the Motion of Bodies after Mutual Impulse," in which the laws of motion are stated in remarkably clear and concise terms.

Jackson, Dr. Charles Thomas, iv, 215. Born at Plymouth, Mass., June 21, 1805; died at Somerville, Mass., Aug. 29, 1880. American physician and geologist. One of the claimants to the discovery of etherization. Also claimant to the invention of a telegraph similar to Morse's.

Jacquard, Joseph Marie, ix, 49. Born at Lyons, France, July 7, 1752; died near Lyons, Aug. 7, 1834. French mechanic and inventor. He invented the Jacquard loom about 1801. Modifications of this loom are still used extensively for weaving designs and patterns.

Jansen (or Zanss) Zacharias, ii, 77. A Dutch

KEY AND INDEX

optician. About 1590 placed a concave and a convex lens respectively at the end of a tube, and used this device for magnifying small objects. This is the first recorded instance of the use of a compound microscope.

Jenner, Edward, iv, 190. Born at Berkeley, England, May 17, 1749; died there Jan. 26, 1823. English physician, the discoverer of vaccination. In investigating the disease known as cowpox, he discovered that after inoculation by this disease the patient was immune from smallpox. This was the basis of his discovery—probably the greatest in medicine previous to his time, and for about two generations following.

Joule, James Prescott, iii, 269. Born at Salford, England, Dec. 24, 1818; died at Sale, Oct. 11, 1889. English physicist. One of the first to expound the doctrine of the conservation of energy. His paper "On the Caloric Effects of Magneto-electricity, and the Mechanical Value of Heat" was published in 1843. Tyndall believed that Joule and Mayer were equally entitled to the credit of this revolutionary discovery.

Jussieu, Antoine and Bernard, de, ii, 303. Antoine, born at Lyons, France, April 12, 1748; died at Paris, Sept. 17, 1836. Bernard, born at Lyons, France, Aug. 17, 1699; died at Paris, Nov. 6, 1776. Two celebrated French botanists, who founded the natural system of the classification of plants. By some authorities the credit of this classification is given to Bernard.

Kadmus (or Cadmus), i, 86. In Greek legend he is reported to have introduced the letters of

BIOGRAPHICAL INDEX

the alphabet. According to the legend, he was the son of a Phœnician king.

Kant, Immanuel, iii, 26. Born at Königsberg, Prussia, April 22, 1724; died there Feb. 12, 1804. Celebrated German philosopher. He conceived the nebular hypothesis which attempted to explain world formation along rational lines. The puzzling questions left unanswered by Kant were answered by Laplace's nebular hypothesis (see Vol. iii, 31).

Kay, John, ix, 22. Born near Bury, Lancashire, July 16, 1704; died in France about 1764-5. English mechanic and inventor. He invented the "flying shuttle," a power loom, and several other aids to weaving. On account of these inventions mobs of workmen wrecked his house, stole his machines, and drove him from the country.

Kay, Robert, ix, 43. Son of John Kay. In 1760 he invented the "drop-box," a device which enabled the weaver to insert several colors as strips across the length of his loom with great facility.

Kelvin, Lord (William Thomson), iii, 165; v, 106. Born at Belfast, Ireland, June 1829; died at London, Dec. 17, 1907. Celebrated British physicist. Active in almost every field of natural philosophy. Took an active part in laying the Atlantic cable, and invented the mirror-galvanometer and siphon-recorder in connection with that work. Was first to maintain that the earth is practically solid to the center and has the rigidity of steel. Invented the short-needle compass now in universal use by mariners. Was

KEY AND INDEX

knighted in 1866, and created Baron Kelvin in 1892.

Kepler, Johann, ii, 70. Born at Weil der Stadt, Württemberg, Dec. 27, 1571; died at Ratisbon, Bavaria, Nov. 15, 1630. One of the founders of modern astronomy. His name is associated with three laws of planetary motion, which are as follows: (1) The orbits of the planets are ellipses having the sun at one focus; (2) The areas described by their radii vectores in equal times are equal; (3) The squares of their periodic times are proportional to the cubes of their mean distances from the sun.

Khamurabi, (Hammurabi), Code of i, 76. King of Babylon about 2000 B.C. He instituted a code of laws older than the laws of either Manu or Moses.

Kirchhoff, Gustav Robert, iv, 69. Born at Königsberg, Prussia, Mar. 12, 1824; died at Berlin, Oct. 17, 1887. German physicist. With Bunsen he discovered the method of spectrum analysis in 1860.

Kleist, Dean von. (See Von Kleist.)

Koch, Dr. Robert, iv, 228. Born at Klansthal, Hanover, Dec. 11, 1843; died May 27, 1910. German bacteriologist. In his study of bacteriology he isolated the anthrax bacillus, and in 1883 announced a method of preventive inoculation against the disease. The year before (1882) he discovered the bacillus of tuberculosis, and eight years later announced the discovery of tuberculin, which he hoped would prove to be a cure for consumption. In 1883 he identified the comma bacillus as the organism responsible for Asiatic cholera.

BIOGRAPHICAL INDEX

Kunz, Dr. George F., v, 101. Born at New York, Sept. 20, 1856. American gem expert. Special agent of the United States Geological Survey in 1883. Had charge of the department of mines, World's Columbian, and Paris Expositions. Has written extensively on gems and minerals. Author of "Gems and Precious Stones of North America," "Mineral Resources of the United States," etc. The recently discovered precious stone kunzite was named in his honor.

Lacaille, Nicolas Louis de, iii, 13. Born at Rumigny, France, March 15, 1713; died at Paris, March 21, 1762. Noted French astronomer. Measured the French arc of the meridian in 1739-41. In 1751 he went to the Cape of Good Hope and made many important observations on the stars of the southern hemisphere. While on this expedition he determined the sun's parallax by observing the parallaxes of Mars and Venus.

Laennec, René Théophile Hyacinthe, iv, 201. Born at Quimper, France, Feb. 17, 1781; died Aug. 13, 1826. French physician. He was the inventor of the stethoscope, an instrument which is of great aid in diagnosis of diseases of the heart and lungs.

Lamarck, Jean Baptiste De, iv, 151. Born at Bazentin, France, Aug. 1, 1744; died at Paris, Dec. 18, 1829. French naturalist. His work helped directly to lay the foundation for Darwin's doctrine of evolution. His views differed from Darwin's about the part played by the active exertion of the organism and by "appetency."

KEY AND INDEX

Langley, S. P., vii, 275. Born at Roxbury, Boston, Mass., Aug. 22, 1834; died at Aiken, S.C., Feb. 27, 1906. American astronomer. In 1887 was appointed secretary of the Smithsonian Institution. Became interested in the problem of aerial flight, and invented the first heavier-than-air machine of any considerable size which could fly by means of self-contained power.

Laplace, Marquis Pierre Simon de, iii, 32. Born at Beaumont-en-Auge, Calvados, France, March 28, 1749; died at Paris, March 5, 1827. Celebrated French astronomer and mathematician. He made important discoveries concerning the inequality of the motions of Jupiter and Saturn, of the moon, and the tides. He developed the nebular hypothesis of cosmogony with such thoroughness that "posterity will always link it with his name."

Lavoisier, Antoine Laurent, iv, 33. Born at Paris, Aug. 16, 1743; died (guillotined) at Paris, May 8, 1794. French chemist, the founder of modern chemistry. He overthrew the "phlogistic" chemistry of the Eighteenth Century. He introduced a new chemical nomenclature which has remained practically unchanged except in the matter of additions, to the present time.

Layard, Sir Henry Austen, viii, 103. Born at Paris, March 5, 1817; died at London, July 5, 1894. English archæologist. He is noted for his archæological discoveries about Nineveh, and his decipherment of the cuneiform characters on the Assyrian monuments.

Lee, Rev. William, ix, 56. Born at Nottingham (date unknown); died at Paris about 1610.

BIOGRAPHICAL INDEX

English clergyman and inventor. About 1589 he invented a knitting machine which would knit at a rate more than ten times faster than could be done by hand. The English hand-knitters opposed the use of this invention, and it was not until after the death of the inventor that his machine was put to practical use.

Leeuwenhoek, Anthony van, ii, 179. Born at Delft, Netherlands, Oct. 24, 1632; died at Delft, Aug. 26, 1723. Dutch microscopist and naturalist. Discovered microbes in the secretions of the mouth in 1683. He also discovered red blood-corpuscles, spermatozoa, and the capillary circulation of the blood.

Leibnitz, Gottfried Wilhelm von, ii, 197. Born at Leipsic, July 6, 1646; died at Hanover, Nov. 14, 1716. German philosopher and mathematician. Called, with reason, "a universal genius." He was the inventor of the differential and integral calculus. He conceived the theory that the entire universe is composed of individual centers, or monads, and deduced the doctrine of pre-established harmony. His influence on the scientific thought of his time was very marked.

Leidy, Joseph, iv, 207. Born at Philadelphia, Sept. 9, 1823; died April 30, 1891. American naturalist. In 1827 he discovered the cyst of "*Trichina spiralis*" in pork. He made important discoveries and wrote extensively on the subject of extinct vertebrate fauna.

Leonardo, Vinci, da, i, 129; ii, 47. Born at Vinci, Italy, 1452; died near Ambrosie, France, May 2, 1519. Famous Italian artist, architect, musician, and scientist. Perhaps the most uni-

KEY AND INDEX

versal genius that ever lived. As a scientist he anticipated Copernicus in determining the movement of the earth, and made elaborate calculations to prove that the earth moves. He invented a dynamometer for determining the traction power of machines and animals, and invented a "steam engine" which "drove a ball weighing one talent over a distance of six stadia." He is credited with the discovery of the camera obscura. He observed the deposit of fossil shells in rocks, and drew the correct conclusion that these had been deposited at the bottom of the sea, even though now resting on the tops of mountains. He drew designs for flying machines of the aeroplane type, with bird-like wings. He was so far in advance of the scientific knowledge of his time that his efforts produced few immediate results.

Lepsius, Karl Richard, i, 27. Born at Naumburg, Prussia, Dec. 23, 1810; died at Berlin, July 10, 1884. German Egyptologist and philologist. His work helped in clearing the field for our present knowledge of ancient Egypt.

Leucippus, i, 161; lived about 500 B.C. Greek philosopher. Originated (with Democritus) the atomic theory of matter.

Lewes, George Henry, i, 131. Born at London, April 18, 1817; died Nov. 30, 1878. English philosophical writer. Wrote extensively in many fields of scientific thought, throwing much light on the Greek philosophers, and, in modern times, such scientists as Comte and Goethe.

Liebig, Baron Justin von, iv, 131. Born at Darmstadt, May 12, 1803; died at Munich, April 18, 1873. German chemist. Celebrated for his

BIOGRAPHICAL INDEX

researches in organic chemistry, and the application of chemistry to food and agriculture. He demonstrated that the source of animal heat is really the consumption of the fuel taken in through the stomach and lungs.

Lilienthal, Otto, vii, 278. Born at Anklam, Germany, May 23, 1848; died Aug. 9, 1896. German engineer and pioneer in aviation. His experiments with gliding machines and his successful flights with various types of gliders gave the impetus to invention that culminated in the invention of the Wright Brothers' aeroplane. He was killed by a fall from one of his gliders.

Linnaeus, Carolus, ii, 299. Born at Rashult, Sweden, May 13, 1707; died at Upsala, Sweden, Jan. 10, 1778. Swedish naturalist and botanist. Founder of the "Linnaeus system" in botany, which has since been supplanted.

Lippershey, Johannes, ii, 78. Died 1619. One of the first to experiment with combinations of lenses to form a telescope. The instrument as constructed by him is still known as the "Dutch Telescope."

Lister, Dr. Joseph (Lord Lister), iv, 229; v, 19. Born April 5, 1827. Noted English surgeon, the father of antiseptic surgery. He began publishing the results of his researches in 1867, but it was not until about ten years later that their full significance had been demonstrated in practical surgery. The rapid advances in surgery made during the past quarter of a century are due largely to Lister's revolutionary discovery.

Lister, Joseph Jackson, iv, 113. Born at London, Jan. 11, 1786; died Oct. 24, 1869. English

KEY AND INDEX

physician. He discovered the principle of aplatic foci, and as a result he greatly improved the construction of object glasses of microscopes.

Lockyer, Sir Norman, v, 73. Born at Rugby, England, May 17, 1836. A noted English astronomer. He is noted for much original work in the field of astronomy, and is an ardent advocate among other things of the theory of the meteoric origin of all members of the sidereal family; and the dissociation theory of the elements, according to which our so-called elements are really compounds, capable of being dissociated into simpler forms when subjected to extreme temperatures, such as pertain in many stars.

Lodge, Sir Oliver, v, 109. Born at Staffordshire, England, June 12, 1851. English physicist. His name is closely associated with the advances in our knowledge of radio activity and the structure of the atom. He has suggested that the instability of the atom may be the result of the atom's radiation of energies.

Long, Dr. Crawford W., iv, 215. An American physician whose name is closely associated with the discovery of etherization. He actually performed painless surgical operations of a minor nature with the use of ether some little time before Morton's demonstration. But he was not sure that the effects produced were not due to hypnotism quite as much as to the drug.

Lotze, Rudolf Hermann, iv, 263. Born at Bautzen, Saxony, May 21, 1817; died at Berlin, July 1, 1881. German physiologist, psychologist, and philosopher. He is remembered as a

BIOGRAPHICAL INDEX

physiologist for his opposition to the theory of a "vital force." His famous paper opposing this doctrine appeared in 1852.

Lubbock, Sir John, iv, 175. Born at London, March 26, 1803; died near Farnborough, Kent, June 20, 1865. Celebrated English mathematician and astronomer. He was one of the first to champion Darwin's theory of evolution. His best known work is "On the Theory of the Moon and on the Perturbations of the Planets."

Ludolff, Christian Friedrich, ii, 276. German scientist, particularly remembered for his demonstration that electric sparks are actual fire. This demonstration was made before the Academy of Science at Berlin in 1744, and consisted of touching the surface of a spoonful of sulphuric ether with a charged glass rod, causing it to burst into flame.

Lyell, Sir Charles, iii, 84. Born at Kinnorby, Forfarshire, Scotland, Nov. 14, 1797; died at London, Feb. 22, 1875. Celebrated British geologist. He is especially famous as an opponent of the old catastrophism in geology, and it was largely through his efforts that this doctrine was finally overthrown. His views were bitterly opposed and were not accepted universally for something like a quarter of a century after he had propounded them.

Magendie, Francois, iv, 203. Born at Bordeaux, France, Oct. 15, 1783; died at Paris, Oct. 7, 1855. A noted French physician, anatomist and physiologist. He was one of the experimental physiologists of the early Nineteenth Century who laid the foundation for modern scientific medicine. He is especially remem-

KEY AND INDEX

bered for his experiments on the physiology of the nerves.

Malpighi, Marcello, ii, 179. Born near Bologna, Italy, March 10, 1628; died at Rome, Nov. 29, 1694. An Italian anatomist and physiologist. He is remembered as the father of microscopic anatomy. As early as the year 1661 he discovered the capillary vessels connecting the veins and arteries by the aid of the microscope. A little later he observed the passage of the blood corpuscles through these minute vessels, making his observations on the lung of a turtle. His work completed the last link of the chain which Harvey had all but established in proving the course of the circulation of the blood.

Marchettis, Peter, ii, 185. (1589-1675.) An Italian physician, one of the leading surgeons of the Seventeenth Century.

Marconi, Guglielmo, viii, 14. Born at Bologna, Italy, April 25, 1874. Italian inventor. Noted for perfecting a system of wireless telegraphy. In 1899 he began sending messages across the English Channel, and this date may be considered as opening the era of wireless telegraphy.

Mariotte, Edme, ii, 210. Born at Burgundy about 1620; died at Paris, May 12, 1684. French physicist. He demonstrated that but for the resistance of the atmosphere, all bodies, whether light or heavy, dense or thin, would fall with equal rapidity. He proved this by the well-known "Guinea-and-feather" experiment—placing a coin and a feather in a tube from which the air had been exhausted, and showing that

BIOGRAPHICAL INDEX

the rate of falling in a vacuum was the same. The name "Mariotte's law" is given to the principle discovered by Boyle that the volume of a given mass of gas varies inversely as the pressure which it bears at any given temperature.

Marsh, Othniel Charles, iii, 107. Born at Lockport, New York, Oct. 29, 1831; died at New Haven, Conn., March 18, 1899. American paleontologist. He is especially remembered for his work in collecting and classifying the fossils found in the Rocky Mountain region. It was he who discovered the earliest progenitors of the horse, the fossil remains of which were found during this extensive work in the West.

Maspero, Gaston Camille Charles, i, 28. Born at Paris, June 24, 1846. French Egyptologist. His best known work is "History of the Ancient People of the Orient."

Maupertius, Pierre Louis Moreau de, iv, 149. Born at St. Malo, France, July 17, 1698; died at Basel, Switzerland, July 27, 1759. French astronomer, mathematician, and philosopher. In 1736-37 he went to Lapland and measured accurately a degree of longitude. He supported the Newtonian theory against the Cartesians, and had conceived vaguely the idea of transmutation of species.

Maury, Matthew Fontaine, iii, 196. Born at Spottsylvania County, Va., Jan. 14, 1806; died at Lexington, Va., Feb. 1, 1873. American naval officer, hydrographer and meteorologist. Advocated a theory of gravitation as the chief cause of ocean currents. He gave the first complete description of the Gulf Stream.

Maxim, Sir Hiram Stevens, vi, 228; vii, 283.

KEY AND INDEX

Born at Sangerville, Me., Feb. 1840. American-English inventor. He is noted for his invention of automatic firearms, and for his studies of aerial navigation. In 1894 he demonstrated that a heavy machine properly equipped with plane-surface could be made to rise from the ground and be sustained by the air.

Maxwell, James Clerk, iii, 44. Born at Edinburgh, Nov. 13, 1831; died Nov. 5, 1879. Scotch physicist. Especially remembered for his studies of the motion of Saturn's rings, and his investigations as to the nature of electricity and magnetism. In 1871 he published his "Theory of Heat," and in 1876, "Matter and Motion."

Mayer, Dr. Julius Robert von, iii, 258. Born at Heilbronn, Württemberg, Nov. 25, 1814; died at Heilbronn, March 20, 1878. German physician and physicist. In 1842 he originated the mechanical theory of heat, and propounded the entire doctrine of the conservation of energy. He was led to his conclusions by the observations made on patients while acting as surgeon on a Dutch India vessel cruising in the tropics.

Mendelèeff, Dmitri Ivanovitch, iv, 68. Born at Tobolsk, Siberia, Feb. vii, 1834. Celebrated Russian chemist. He was the discoverer of the periodic system of the chemical elements. This discovery had enabled Mendelèeff to predicate the existence of new elements years before they were discovered.

Mercator (right name Gerhard Kremer), vii, 30. Born at Rupelmondo, Belgium, March 5, 1512; died at Dinsburg, Prussia, Dec. 2, 1594. Flemish geographer. Remembered particularly

BIOGRAPHICAL INDEX

for his invention of the Mercator system of projection of maps.

Meyer, Lothar, iv, 68. He conceived the so-called "Law of Octaves" afterward fully explicated by Mendeléeff (q.v.) under the title of "The Periodic Law."

Mohl, Hugo von, iv, 125. (See von Mohl.)

Mohr, Karl Friedrich, iii, 257. Born at Coblenz, Germany, Nov. 4, 1806; died at Bonn, Sept. 27, 1879. German chemist and physicist. He was first to state the doctrine of the conservation of energy which he had independently conceived. He did not demonstrate the validity of his conception as clearly as Mayer did five years later, but his conception is apparently the first ever recorded.

Moissan, Prof. Henri, ix, 328. Born at Paris, Sept. 28, 1852; died Feb. 20, 1907. French chemist. Noted for his accomplishments with the electric furnace. In 1892 discovered a method of manufacturing acetylene at a cost that is commercially profitable. In 1893 formed diamonds from iron melted in an electric furnace and cooled suddenly.

Mondino of Bologna, ii, 37. Born in 1276; died in 1326. An Italian physician known as the "restorer of anatomy." He is known to have made careful dissections of the human body, and his writings on anatomy based on his observations were a step in advance over the generally accepted writings of Galen.

Montgolfier, Joseph Michel, vii, 230. Born at Ardèche, France, 1740; died at Balarnc, France, June 26, 1810. French mechanician and in-

KEY AND INDEX

ventor. With his brother invented the hot-air balloon, a public exhibition being given in 1782.

Montgolfier, Stephen, vii, 230. Born at Ardèche, France, Jan. 7, 1745; died in Servieres, Aug. 2, 1799. French mechanician and inventor (with his brother Joseph, q.v.) of the hot-air balloon.

Morgagni, Giovanni Battista, iv, 76. Born at Forli, Italy, Feb. 25, 1682; died at Padua, Italy, Nov. 5, 1771. An Italian physician and anatomist. He made exhaustive studies of the structure of diseased tissue both during life and post-mortem, and as he was one of the first to investigate this subject he is one of the founders of pathological anatomy. From the time of the publication of Morgagni's researches morbid anatomy became a recognized branch of medical science.

Morgan, Lewis Henry, vi, 25. Born at Aurora, N. Y., Nov. 21, 1818; died at Rochester, N. Y., Dec. 17, 1881. American archæologist and anthropologist. He was first to give a scientific account of the organization and government of the Indian tribe.

Morse, Samuel F. B., viii, 17. Born at Charlestown, Mass., April 27, 1791; died at New York, April 2, 1872. American artist and inventor of the electric telegraph. He began life as a portrait painter, but turned his attention to invention, and in 1832 designed an electric telegraph. He applied for a patent in 1837, and in 1844 a line of telegraph was completed between Baltimore and Washington, an appropriation for its construction having been granted by Congress the year before.

BIOGRAPHICAL INDEX

Morton, Dr. William Thomas Greene, iv, 214. Born at Charlton, Mass., Aug. 9, 1819; died at New York, July 15, 1868. An American dentist, the discoverer of etherization. On October 16, 1846, Dr. Morton administered ether to a patient in the Massachusetts General Hospital, at Boston, and Dr. Warren performed a difficult operation, the removal of a tumor from the patient's neck. This operation inaugurated the era of painless surgery for which Dr. Morton's discovery is responsible.

Müller, Johannes, iv, 122. Born at Coblenz, Germany, July 14, 1801; died at Berlin, April 27, 1858. German physiologist and comparative anatomist. He was one of the founders of modern physiology.

Murdoch, William, vi, 207; vii, 158. Born at Auchinleck, Ayrshire, Aug. 21, 1753; died at Birmingham, Nov. 15, 1839. Scottish inventor. He was associated with Watt in Birmingham, and in 1795 first made use of illuminating gas at that place. He was the inventor of the oscillating steam-engine.

Musschenbroek, Peter van, ii, 280. Born at Leyden, Netherlands, March 14, 1692; died there Sept. 19, 1761. Dutch natural philosopher and mathematician. One of the discoverers of the Leyden jar. His discovery was made at about the same time as that of Dean von Kleist, but independently.

Newcomb, Simon, vii, 39. Born at Wallace, Nova Scotia, March 12, 1835; died in 1910. American astronomer. Professor of Mathematics in the United States Navy in 1861; in 1884, Professor of Mathematics and Astronomy at

KEY AND INDEX

Johns Hopkins University. Wrote popularly on astronomy and political economy.

Newcomen, Thomas, vi, 89. Born in 1663; died in August, 1729. English inventor. He invented (with Cawley and Savery) the atmospheric steam-engine, which was patented in 1705.

Newlands, John A. R., iv, 67. Born in England, 1838; died at London, July 29, 1898. An English chemist. He was one of the first to propound the conception of the periodicity among the chemical elements. (See Mendelèeff.)

Newton, Sir Isaac, ii, 236. Born at Woolsthorpe, near Grantham, England, Dec. 25, 1642 (O.S.); died at Kensington, March 20, 1727. English mathematician and natural philosopher. Discoverer of the law of universal gravitation. (See Vol. II, pp. 236-251.)

Nicholson, William, iii, 232. Born at London, 1753; died in 1815. English physicist and chemist. He (with Carlisle) decomposed water into its elements, hydrogen and oxygen, by galvanism in 1800.

Oersted, Hans Christian, iii, 236. Born at Rudkjobing, Denmark, Aug. 14, 1777; died March 9, 1851. A Danish physicist. In 1819 he discovered electro-magnetism by passing a current of electricity through a wire held parallel with, but not quite touching, a suspended magnetic needle.

Oken, Lorenz, iv, 160. Born at Bolsbach, Swabia, Aug. 1, 1779; died at Zurich, Aug. 11, 1861. German naturalist and natural philosopher. In a work published during his professorship in the University of Zurich he outlined

BIOGRAPHICAL INDEX

a theory of spontaneous generation and of evolution of species.

Olbers, Heinrich Wilhelm Matthias, iii, 40. Born near Bremen, Germany, 1758; died at Bremen, March 2, 1840. German physician and astronomer. He discovered several comets and the planetoids, Pallas and Vesta, and discovered a method of calculating cometary orbits.

Owen, Sir Richard, iv, 207. Born at Lancaster, England, July 20, 1804; died at London, Dec. 18, 1892. English paleontologist and comparative anatomist. From 1836-1856, he was Hunterian Professor of Anatomy and Physiology in the London College of Surgeons. He was conspicuous in the field of microscopy, and in 1833 discovered the "*Trichina spiralis*" in the tissues of the human body.

Paget, Sir James, iv, 207. Born at Yarmouth, England, Jan. 11, 1714; died at London, Dec. 30, 1809. English physician and surgeon. He discovered the presence of "*Trichina spiralis*" in human muscular tissue while a student in St. Bartholomew's Hospital in 1833. At one time president of the Royal College of Surgeons.

Papin, Denis, vi, 88. Born at Blois, France, Aug. 22, 1647; died in 1712. French physicist. As early as 1688 he conceived the idea of making use of a piston working tightly in a cylinder, and a little later added the idea of producing a vacuum in a cylinder—steps toward the invention of the steam-engine.

Paracelsus, Philippus Aureolus, ii, 159. Born at Switzerland, Dec. 17, 1493; died at Salzburg, Sept. 23, 1541. German-Swiss physician and alchemist. He gave a great impetus to the study

KEY AND INDEX

of pharmaceutical chemistry and the use of drugs. It is claimed (upon doubtful authority), that he introduced the use of opium and mercury in medicine.

Paré, Ambroise, ii, 181. Born at Laval, Mayenne, France, 1517; died at Paris, Dec. 22, 1590. Celebrated French surgeon. One of the founders of scientific surgery. Noted for his discovery of a rational method of treating gunshot wounds. He introduced the use of the ligature for controlling hemorrhage.

Parmenides, i, 114. Lived about the middle of the Fifth Century, B.C. Greek philosopher. His writings were held in high esteem by both Plato and Aristotle.

Parsons, C. A., vi, 124. Born June 13, 1854. English engineer, inventor of the practical steam turbine engine. These engines have been found particularly effective for the generating of electricity and the propulsion of war and mercantile vessels.

Pascal, Blaise, ii, 122. Born at Clermont-Ferrand, Puy-de-Dôme, June 19, 1623; died at Paris, August 19, 1662. Celebrated French philosopher and writer. In 1648 Pascal suggested that if the theory of the pressure of the air upon the mercury in a Torricellian barometer was correct, it could be demonstrated by ascending a mountain with the mercury tube. As the air was known to get progressively lighter from base to summit, the height of the column should be progressively lessened as the ascent was made, and increase again on the descent into the denser air. This experiment was made shortly after this time, the rising and falling

BIOGRAPHICAL INDEX

of the mercury proving the correctness of the theory of atmospheric pressure.

Pasteur, Louis, iv, 217. Born at Dole, Jura, France, Dec. 27, 1822; died near St. Cloud, Sept. 28, 1895. Celebrated French chemist and microscopist. Noted for his studies on fermentation and his researches in bacteria. Remembered particularly for his experiments with anthrax bacillis and the prevention of the disease in domestic animals caused by this germ. Also for his experiments and demonstrations in the prevention of hydrophobia by inoculation.

Paul of Aegina, ii, 31. Born about 620; died about the year 690. A Byzantine physician. He was one of the Alexandrian school of physicians who was far ahead of his time in his knowledge of surgery. He discarded the prevalent idea of the supernatural cause of disease and practiced his profession along rational scientific lines. He performed many modern operations, among others those within the abdominal cavity.

Perraudin, iii, 145. A chamois hunter, who in 1815 noted the markings of glaciers on the rocks in the Alps and reached the correct conclusion that these scratches were caused by glaciers in former times. His conception was laughed at at first by scientists, but later accepted as a true explanation of what are now known as glacial scratches.

Peter of Abano, ii, 36. Born in 1250; died in 1315. A celebrated mediæval physician who advocated rational methods in the treatment of diseases, maintaining that such diseases were of natural rather than of supernatural causation. He was one of the first great men produced by

KEY AND INDEX

the University of Padua. He is remembered particularly for his teachings that the brain is the source of the nerves, and the heart the source of the vessels.

Petrie, W. M. Flinders, i, 28. Born June 30, 1853. An English Egyptologist who has made many important discoveries of Egyptian relics which give clues to the history of the early Egyptian civilization.

Piazzi, Giuseppe, iii, 40. Born at Ponte, Valtellina, Italy, July 16, 1746; died at Naples, July 22, 1826. Italian astronomer. On January 1, 1801, observed an apparent star which he supposed to be a comet. Later it proved to be the planet Ceres, occupying a position in space between Mars and Jupiter.

Pickering, Edward Charles, iii, 65. Born at Boston, July 19, 1846. American astronomer, Professor of Astronomy and Dir. Harvard College Observatory since 1876. Made exhaustive study of light and spectra of the stars. Made over one million measures of the light of stars with a meridian photometer invented by him. Author of "Elements of Physical Manipulation," and many papers on scientific subjects.

Pinel, Dr. Philippe, iv, 245. Born at St. André, Tarn, France, April 20, 1745; died at Paris, Oct. 25, 1826. French physician. In 1795, at La Salpêtrière, an asylum for the care of the insane, he struck off the shackles from the inmates and took the revolutionary attitude of treating them as persons afflicted by disease, not "possessed by demons."

Planché, Gaston, iii, 246. French inventor. In 1859 he invented the first reasonably satisfac-

BIOGRAPHICAL INDEX

tory storage battery. His battery was constructed of sheets of lead immersed in dilute sulphuric acid.

Plato, i, 180. Born at Ægina, 429 or 427 B.C.; died at Athens, 347. Greek philosopher. He was a great ethical teacher, but seems to have had no clearly defined opinions as to the mechanism of the universe; no clear conception as to the origin of development of organic beings; no tangible ideas as to the problems of physics; no favorite dreams as to the nature of matter.

Playfair, John, iii, 131. Born at Benvie, Forfarshire, March 10, 1748; died at Edinburgh, July 19, 1819. Scottish physicist. One of the ardent champions of Hutton's theory of constant changes taking place in the earth's crust. With Lyell, he conceived that the changes on the surface of the earth have always been the same in degree as well as in kind. Modern physicists do not accept this.

Pliny (Caius Plinius Secundus), i, 265. Born at Como, Italy, 23 A.D.; died in the eruption of Vesuvius, 79 A.D. Celebrated Roman naturalist. He wrote his famous work on "Natural History" while campaigning as a soldier of the Roman Empire. It is a vast work in which some four thousand works are either cited or quoted from. In the history of scientific principles it may be virtually disregarded, but it is important in the history of the promulgation of knowledge.

Polybius, i, 201. Born at Megalopolis, Arcadia, Greece, 204 B.C.; died about 125 B.C. Celebrated Greek historian. It is through his wri-

KEY AND INDEX

tings that much of the life work of Archimedes is known. Many of the mechanisms invented by him are also described.

Pouchet, M. F. A., iv, 180. A French scientist who advocated the theory that organic beings are generated about us constantly in the familiar processes of putrefaction which are known to be due to the agency of microscopic bacteria. In 1862 Louis Pasteur proved that this seeming spontaneous generation is in reality due to the existence of germs in the air.

Prestwich, Sir Joseph, iii, 101. Born at Clapham, London, March 12, 1812; died at Shoreham, Kent, June 23, 1895. Noted English geologist. With Mr. (afterward Sir John) Evans he made important excavations and investigations of fossil remains and prehistoric implements found at Abbeville and other places in 1859. His discoveries helped to establish the correctness of the theory of evolution.

Priestley, Joseph, iv, 20. Born near Leeds, Yorkshire, March 13, 1733; died at Northumberland, Pa., Feb. 6, 1804. Celebrated English clergyman and natural philosopher. Noted for his general experiments with gases, and in particular for his discovery of oxygen. He wrote a "History of Electricity" at the suggestion of Benjamin Franklin.

Proust, Louis Joseph, iv, 41. Born at Angers, 1755; died in 1826. French chemist. His work led to the establishment of the principle that chemical compounds are of fixed proportions, however prepared.

Ptolemy (Claudius Ptolemæus), i, 267. Born at Alexandria; died first half of Second Cen-

BIOGRAPHICAL INDEX

Plato, A.D. Astronomer, geographer, and mathematician. The last great astronomer of antiquity. His mathematical system of astronomy was accepted for several centuries until finally displaced by the system of Copernicus.

Pythagoras, i, 112. Born at Samos, Greece, about 582 B.C.; died at Metapontum, Magna Græcia, about 500 B.C. Famous Greek philosopher and mathematician. He is said to have been the first to advocate that the earth is a sphere.

Ramon y Cajal, Dr. **Santiago**, iv, 283. Born at Petite de Aragon, Spain, 1852. Spanish physician and histologist. Professor of Histology in Barcelona and Madrid. Received one of the Nobel prizes, 1906.

Ramsay, Sir **William**, v, 86. Born at Glasgow, Oct. 2, 1852. Scotch chemist. In 1894 (with Lord Rayleigh) he discovered argon. He isolated helium, krypton, neon, and xenon. In 1896 he published "The Gases of the Atmosphere and the History of their Discovery."

Rawlinson, **Canon**, i, 82. Born at Chadlington, Oxfordshire, Nov. 23, 1812; died at Canterbury, Oct. 6, 1902. English theologian, historian, and Orientalist. His histories of the ancient Oriental peoples have thrown much light on the scientific knowledge of their time.

Rawlinson, Sir **Henry**, iv, 229; v, 9. Born at Chadlington, Oxfordshire, April 11, 1810; died at London, March 5, 1895. English Assyriologist. He wrote extensively on Assyriology, giving a clear insight into the status of science among the Assyrians and Chaldeans.

Rayleigh, **Lord**, v, 86. Born Nov. 12, 1842. English physicist. For eleven years he was sec-

KEY AND INDEX

retary of the Royal Society. He was associated with Prof. William Ramsay in the discovery of the new gas, argon, which forms approximately 1 per cent of the atmosphere.

Réamur, René, iv, 88. Born at La Rochelle, France, Feb. 28, 1683; died at Bermondiere, Maine, France, Oct. 18, 1757. French naturalist and physicist. He discovered the method of making the porcelain named for him and invented the Réamur thermometer. In the scale of this thermometer there are 80 degrees between the freezing-point and the boiling-point of water.

Rhazes, Arabian physician, ii, 24. Born at Raj, Persia, about 850; died about 932. An Arabian physician, philosopher and musician. He introduced the use of mercurial ointment, sulphuric and nitric acid, in therapeutics. He is credited with being the first physician to describe small-pox and measles accurately.

Roentgen, Professor Wilhelm Conrad, iii, 248. Born at Leinsep, Prussia, March 27, 1845. German physicist. He has made several important discoveries, but the importance of these is completely overshadowed by his discovery, in 1896, of the Roentgen rays, or X-rays. For this discovery he was awarded the Nobel prize in 1901.

Rougé, Olivier Charles de, i, 27. Born at Paris, April 11, 1811; died at Chateau Bois-Dauphin, Dec. 31, 1872. Celebrated French Egyptologist. Remembered particularly for his discovery of the prototypes of the Semitic alphabet in the early Egyptian hieratic.

Rumford, Count, iii, 208; v, 30. Born at Woburn, Mass., March 26, 1753; died at Auteuil, near

BIOGRAPHICAL INDEX

Paris, Aug. 21, 1814. An American scientist. As aide-de-camp and chamberlain at the court of the Elector of Bavaria, he reorganized the Bavarian Army. His greatest discovery, that heat is a form of motion, was discovered while boring cannon for the defense of Munich.

Rush, Dr. Benjamin, iv, 245. Born near Philadelphia, Dec. 24, 1745; died at Philadelphia, April 19, 1813. American physician. Remembered in particular for his attitude toward patients suffering from mental disorders.

Rutherford, Prof. Ernest, v, 105. Born at Nelson, New Zealand, 1871. In 1898, was appointed Professor of Physics in McGill University, Montreal. He has written extensively on the conduction of electricity through gases, and on radio-activity. In 1904 he published "Radio-activity."

Saint-Hilaire, Etienne Geoffrey, iv, 160. Born at Étampes, April 15, 1772; died at Paris, June 19, 1844. Noted French zoologist. He championed the theory of the transmutation of species against Cuvier, but the truth of his arguments was not fully appreciated until after his death.

Santos-Dumont, Alberto, vii, 266. Born at San Paulo, Brazil, July 20, 1873. Brazilian aeronaut. Experimented with balloons in 1898, and in that year constructed his first dirigible balloon. After building several balloons and having several narrow escapes, he finally, on October 19, 1901, won the Henri Deutsche prize of 100,000 francs by flying from the Aero Club at Saint Cloud around the Eiffel Tower and back

KEY AND INDEX

to the starting point in a few seconds less than half an hour.

Savery, Thomas, vi, 85. Born at Shilstone, near Modbury, Devonshire, about 1650; died at London, May, 1715. English engineer. He is remembered particularly for his invention of a machine for raising water from mines by means of steam power. This device, patented in 1698, represented the first application of steam power for mechanical purposes.

Scheele, Karl William, iv, 23. Born at Shalsund, Dec. 2, 1742; died at Köping, Sweden, May, 1786. A celebrated Swedish chemist. He discovered oxygen independently, and without knowing that Priestley had already discovered it. He also discovered many other important substances, such as arsenic acid, lactic acid, tartaric acid, ammonia, and chlorine, this last being of great value commercially for bleaching.

Schiaparelli, Giovanni Virginio, iii, 35. Born at Savigliano, Italy, March 4, 1835. Italian astronomer. The first to point out that meteor swarms move in the orbits of pre-existing comets, and are the débris of comets.

Schleiden, Dr. M. J., iv, 118. Born at Hamburg, April 5, 1804; died at Frankfort-on-the-Main, June 23, 1881. German botanist. The first to demonstrate the all-importance of cell-nucleii in the economy of the cell.

Schoenlein, J. L., iv, 208. A German physician who, in 1839, made the discovery that favus, a distressing disease of the scalp, is due to the presence of a microscopic vegetable organism. This was a step toward the later discovery

BIOGRAPHICAL INDEX

that many other diseases are caused by bacteria.

Schultze, Max Johann Sigismund, iv, 125. Born at Freiburg, Baden, March 25, 1825; died at Bonn, Prussia, Jan. 16, 1874. German anatomist and biologist. Remembered particularly for his researches on protoplasm, and his demonstrations that vegetable protoplasm and animal sarcode are to all intents and purposes identical.

Schwann, Theodor, iv, 119. Born at Neuss, Prussia, Dec. 7, 1810; died at Cologne, Jan. 14, 1882. Distinguished physiologist. He is remembered particularly as the founder of the cell-theory. He made important investigations of muscular and nervous tissues, and was the discoverer of pepsin.

Scrope, G. Poulett, iii, 132. Born at London, 1797; died Jan. 19, 1876. English geologist. In 1823 he published a classical work on volcanoes in which he claimed that volcanic mountains are merely accumulated masses of lava belched forth from a crevice in the earth's crust.

Servetus, Michael, ii, 168. Born at Tudela, Spain, 1511; burned at Geneva, Oct. 27, 1553. Spanish physician and philosopher. He discovered and described the pulmonary circulation, and that the fluids contained in veins and arteries are the same. He showed that the blood is purified by respiration in the lungs, and asserted that there are vessels in the lungs "formed out of vein and artery."

Siemens, Werner, vi, 178; vii, 181. Born at Lenthe, near Hanover, Dec. 13, 1816; died at Berlin, Dec. 6, 1892. German inventor and man-

KEY AND INDEX

ufacturer. He is noted for his experiments in electricity, his work having a direct effect in the final perfecting of the dynamo.

Siemens, Sir William, vi, 195. Born at Lenthe, near Hanover, April 4, 1823; died at London, Nov. 19, 1883. German-English physicist and inventor; brother of Werner Siemens. In 1859 he became a naturalized British subject. He made extensive researches in the field of heat and electricity.

Simpson, Sir J. Y., iv, 217. Born at Bathgate, Scotland, June 7, 1811; died May 6, 1870. Scottish physician. Noted for his introduction of chloroform as an anæsthetic about one year after Morton's demonstration of etherization.

Singer, Isaac M., ix, 97. Born at Oswego, N. Y., Oct. 27, 1811; died at Torquay, England, July 23, 1875. American machinist and inventor. He improved the sewing-machine, bringing it to a practical stage of perfection.

Sloane, Sir Hans, v, 4. Born at Killyleagh, County Down, Ireland, April 16, 1660; died at London, Jan. 11, 1753. British physician and naturalist. Virtually the founder of the British Museum. His collection of curios, which he turned over to the British Government for a nominal sum, formed the nucleus for the present museum.

Smith, William, iii, 74. Born at Churchill, Oxfordshire, England, March 23, 1769; died at Northampton, England, Aug. 28, 1839. An English surveyor who is known as "the Father of English Geology" through his studies of fossils. He discovered that fossils in rocks are arranged in regular systems, and that the order of succes-

BIOGRAPHICAL INDEX

sion of such groups of fossils is always the same in any vertical series of strata in which they occur.

Snell (or **Snellius**), **Willebrord**, ii, 119. Born at Leyden, 1581; died Oct. 30, 1626. Dutch mathematician. About the year 1621, while Professor of Mathematics at Leyden, he discovered the law of refraction.

Spallanzani, **Lazzaro**, iv, 86. Born at Scandiano in Modena, 1729; died in 1799. Remembered chiefly for his discoveries and investigations in the biological sciences. He refuted the evidence of Needham that minute organisms form spontaneously in solutions of meat in water after boiling, by demonstrating conclusively that if properly protected from the atmosphere no organism will form. He discovered the function of the ovum and spermatozoon, and demonstrated that digestion is a chemical process by an ingenious use of tubes filled with food introduced into the stomach.

Spencer, **Herbert**, iv, 268. Born at Derby, April 27, 1820; died at Brighton, Dec. 8, 1903. English philosopher, founder of the system known as synthetic philosophy. He studied engineering and during 1837-46 was employed as a railway engineer. From 1846 he devoted himself to literary work, acting as sub-editor of the "Economist" from 1848 to 1853. In 1850 he published "Social Statics"; and in 1855, "Principles of Psychology." He began his "Synthetic Philosophy" in 1860, completing it in 1896. He was in sympathy and closely in touch with the work of Darwin and Huxley, and in his writings he tried "to express in a sweeping general formula the

KEY AND INDEX

belief in progress which pervaded his age." He was essentially a thinker and writer, rather than an active worker in scientific fields.

Spurzheim, Dr. Kasper, iv, 248. Born at Longwich, near Treves, Dec. 31, 1776; died at Boston, Nov. 10, 1832. A German phrenologist. He was a disciple of Gall, and wrote a physiognomical system with him. He wrote also on philosophy and anatomy.

Stahl, George Ernst, iv, 6, 185. Born at Auspach, 1660; died at Berlin, 1734. German physician and chemist. Famous as the author of the phlogiston theory (q.v.). Champion of the "Animist" theory in medicine.

Stephenson, George, vi, 114; vii, 124. Born at Wylam, near Newcastle, June 9, 1781; died near Chesterfield, Aug. 12, 1848. English inventor, the perfecter of the locomotive. As early as 1814 he constructed a locomotive that could propel itself along the rails, and in 1825 a locomotive made by him actually hauled a train of cars with passengers. His locomotive "Rocket," made in 1829, however, is the prototype of modern locomotives.

Stevinus, Simon, ii, 102. Born at Bruges, 1548; died at The Hague (on Leyden), 1620. Celebrated Dutch mathematician. About 1600 he invented a carriage propelled by sails, in which he carried the Prince of Orange and six other passengers at a speed said to have been much faster than that of horses. In the history of science he is remembered as one of the founders of the science of dynamics and the science of statics.

Strabo, i, 255. Born at Amasia, Pontus, about 63 B.C.; died about 24 A.D. Celebrated Greek

BIOGRAPHICAL INDEX

geographer. Through his writings a good idea of the status of the sciences in his day is gained. He considered the earth a globe, and had a very definite idea of its size. The habitable portion, according to him, extended from Ireland to Ceylon.

Struve, F. G. W., iii, 58. Born at Altona, Germany, April 15, 1793; died at St. Petersburg, Nov. 23, 1864. A German Russian astronomer. He is remembered particularly for his researches on double stars.

Swammerdam, John, ii, 297. Born at Amsterdam, Feb. 12, 1637; died there Feb. 15, 1680. Dutch naturalist. He was educated for the ministry, but turned to the profession of medicine. Later he devoted himself to the study of insects, and his work laid the foundation of the modern science of entomology.

Sydenham, Thomas, ii, 189. Born in Dorsetshire, England, 1624; died at London, December, 1689. Famous English physician. He studied predisposing causes of diseases, and anticipated modern practice in his methods of treating them. In general terms his was what might be termed "rational" treatment. He is remembered particularly for his introduction of the use of laudanum.

Sylvius, Franz, ii, 186. Born at Hanau, Prussia, 1614; died at Leyden, 1672. Celebrated German physician. He founded the "Iatrochemical" school of medicine, whose fellows used medicines and did not accept the "humoral" pathology. One of the fissures in the brain (fissure of Sylvius) is named for him.

Symington, William, vii, 67. Born at Lead-

KEY AND INDEX

hills, Scotland, 1763; died at London, March 22, 1831. British engineer and inventor. Studied for the ministry, but later became a civil engineer. He improved the steam-engine, and in 1802 he produced the steam tugboat "Charlotte Dundas," which was practical commercially.

Tait, Professor P. G., iii, 291; v, 208. Born April 28, 1831; died July 4, 1901. Scottish physicist and mathematician. Made extensive studies, with Lord Kelvin, of the vortex theory of matter. Was an authority on quaternions, and made many important investigations in heat and electricity.

Talbot, William Henry Fox, i, 71. Born Feb. 11, 1800; died at Laycock Abbey, Wiltshire, Sept. 17, 1877. English antiquary. He discovered a process of photography about the same time as did Daguerre, and in 1841 invented the calotype process. He was one of the first to decipher the Assyrian inscriptions found at Nineveh.

Tesla, Nikola. Born at Smiljan, Lika, Austria-Hungary, 1857. Physicist and electrician. Came to the United States in 1884, and later became a naturalized citizen. Invented the system of alternating current power transmission, particularly known as 2-phase, 3-phase, multi-phase, and poly-phase, in 1888. Has been actively engaged in investigating wireless lighting systems, and wireless means of communication.

Thales, i, 103. Born at Miletus, Asia Minor, about 640 B.C.; died about 546. Greek astronomer, and philosopher. He is said to have predicted an eclipse of the sun which took place in the year 585 B.C.

Theophrastus, i, 188. Born at Eresus, Lesbos,

BIOGRAPHICAL INDEX

about 372 B.C.; died 288 or 287 B.C. Greek philosopher. He was a disciple of Aristotle. Because of his work on botany, called "The Natural History of Development," he is called the "father of botany."

Thompson, Benjamin. (See Count Rumford.)

Thomson, Prof. J. J., v, 92. Born near Manchester, Dec. 18, 1856. English physicist. Professor of Physics, Royal Institution, London, since 1905. Especially noted for his researches in electricity and magnetism, and his exhaustive writings on these subjects. May be said to be the discoverer of the negative "electron," or unit "corpuscle" of electricity.

Thomson, Thomas, iv, 44. Born at Crieff, April 12, 1773; died near Holy Loch, July 2, 1852. British chemist. He discovered a large number of chemical compounds, such as chlorochromic and hyposulphurous acid, and many salts.

Thomson, William. (See Lord Kelvin.)

Torricelli, Evangelista, ii, 120. Born at Piancaldoli, Italy, Oct. 15, 1608; died at Florence, Oct. 25, 1647. Italian mathematician and physicist. He was a friend of Galileo, and his successor as professor at Florence. He is remembered particularly for his invention of the barometer in 1643.

Treviranus, Gottfried Reinhold, iv, 159. Born at Bremen, Feb. 4, 1776; died Feb. 16, 1837. German naturalist. He was one of the early workers in biological fields, and one of the first to suggest the name "biology" for that science.

Trevithick, Richard, vi, 103; vii, 75. Born at Cornwall, England, April 13, 1771; died April 22, 1833. Engineer and inventor of the locomotive.

KEY AND INDEX

Constructed his first locomotive in 1800. Between 1801 and 1803 he ran road locomotives about London, carrying passengers. He constructed a high-pressure threshing engine in 1812. His plunger pole pump, invented in 1797, superseded all others for deep mining, and is still in use.

Tuke, Dr. William, iv, 245. Born at York, in 1732; died in 1822. English physician and philanthropist. Remembered particularly for his revolutionary method of caring for the insane, freeing them from chains, and allowing them greater liberty than heretofore.

Tycho, Brahe, ii, 65. Born at Scandia, Sweden, Dec. 14 (O.S.), 1546; died at Prague, Bohemia, Oct. 24 (N.S.), 1601. Celebrated Danish astronomer; among the most famous of star-gazers. He did not accept the Copernican doctrine in full, regarding the earth as an exception to the other planets which have the sun as their center of motion.

Tyndall, John, iv, 175. Born at Leighlin Bridge, Ireland, Aug. 21, 1820; died at Haslemere, Surrey, Dec. 4, 1893. Distinguished British physicist. Especially noted for his popular exposition of scientific subjects, and for his important investigations in electricity, heat, light, and acoustics. He devoted much time to the investigation and study of glaciers, and wrote extensively concerning them. He was an ardent champion of the Darwinian theory from the time of its promulgation.

Van Helmont, Jean Baptista, ii, 185. Born at Brussels, 1578; died at Brussels, Dec. 30, 1644. A Flemish chemist and physician. He con-

BIOGRAPHICAL INDEX

structed a system of medicine which had quite a following until after his death. He coined and first used the word "gas," and is said to have demonstrated the necessity of using the balance in chemistry.

Vesalius, Andrew, ii, 164. Born at Brussels, Dec. 31, 1514; died in the Island of Zante, Oct. 15, 1564. Noted Belgian physician and anatomist. He is called the "greatest of anatomists." His work, "*De corporis humani fabrica, libri septem*" was the first comprehensive and systematic work on humane anatomy.

Virchow, Rudolf, iv, 127; v, 188. Born at Schivelbein, Pomerania, Oct. 13, 1821; died at Berlin, Sept. 5, 1902. Celebrated German physician, anatomist, and anthropologist. He was the founder of cellular pathology. Throughout his life he was active as a teacher, in laboratory work and hospital clinic. During his later years he was also active as a statesman.

Volta, Alessandro, iii, 230. Born at Como, Italy, Feb. 18, 1745; died there March 5, 1827. Celebrated Italian physicist. He is famous for his invention of the voltaic pile. This invention furnished a method of generating galvanic electricity, and is the direct prototype of modern galvanic batteries. It was one of the most revolutionary inventions in the field of electricity. Volta also invented an electroscope, electrophore and condenser.

Von Baer, Karl Ernst, iv, 122. Born at Esthonia, Russia, Feb. 28, 1792; died at Dorpat, Nov. 28, 1876. Celebrated Russian naturalist and embryologist. Von Baer's studies in embryology were the basis of Schwann's discovery that "there

KEY AND INDEX

is one universal principle of development for the elementary parts of organisms, however different, and this principle is the formation of cells."

Von Guericke, Otto, ii, 211. Born at Magdeburg, Prussia, Nov. 20, 1602; died at Hamburg, May 11, 1686. Celebrated German natural philosopher. He invented the air-pump in 1650. He constructed the "Magdeburg hemispheres"—two hollow hemispheres which, when placed together and exhausted could not be pulled apart by teams of horses.

Von Kleist, Dean, ii, 280. A physicist of Cammin, Pomerania, who in 1745 invented the Leyden jar. This discovery is sometimes credited to Musschenbroek, then one of the foremost teachers of Europe; but there is no doubt that von Kleist's discovery antedated Musschenbroek's by a few months.

Von Mohl, Dr. Hugo, iv, 123. Born at Stuttgart, Würtemberg, April 8, 1805; died Tübingen, April 1, 1872. German botanist. Noted for his studies on the cell contents, and for his invention of the word protoplasm, to designate the "physical basis of life."

Wallace, Alfred Russel, iv, 172. Born at Usk, Monmouthshire, England, Jan. 8, 1822; English naturalist. On July 1, 1858, simultaneously with Darwin, he announced the theory of natural selection, although Darwin's theory had been announced privately a year before.

Watson, William, ii, 284. An English physicist. He coined the word "circuit" as used in electricity. In 1747, in an experiment of conducting a current of electricity across London Bridge, using the water of the Thames to complete the

BIOGRAPHICAL INDEX

circuit, he discovered the superiority of wire over chain as a conducting medium.

Watt, James, iv, 14. Born at Greenock, Scotland, Jan. 19, 1736; died near Birmingham, Aug. 19, 1819. Celebrated English engineer and mechanic, the perfecter of the practical steam engine. Among his scientific achievements he claimed to have first discovered the composition of water. Englishmen credit Cavendish with this discovery, but in France Watt's claim is very generally accepted.

Weber, E. H., iv, 263. Born at Wittenberg, Prussia, June 24, 1795; died at Leipsic, Jan. 26, 1878. German physiologist. After exhaustive experiments to test the effects of various nervous stimuli, he reached conclusions which later Fechner christened "Weber's fundamental law of psycho-physics."

Wedgwood, Josiah, iii, 206. Born at Burslem, England, July 12, 1730; died near Newcastle-under-Lynne, Jan. 3, 1795. Celebrated English potter. Inventor of the clay pyrometer, which first enabled scientists to gauge high temperatures accurately.

Weismann, August, iv, 179. Born at Frankfort-on-the-Main, Jan. 17, 1834. Noted German zoologist. He promulgated a theory (in 1883) which denies that individual variations are transmissible. This view antagonizes the Lamarckian conception of acquired variations, which was generally conceded to complement the Darwinian factor of natural selection in effecting the transmutation of species.

Wells, Dr. Horace, iv, 213. A dentist of Hartford, Connecticut, who in 1844 administered ni-

KEY AND INDEX

trous oxide gas and performed the operation of extracting a tooth painlessly. This was two years before Morton discovered etherization.

Wells, Dr. W. C., iii, 184. Born in America, but spent his life in Great Britain. In 1816 he published his "Essay on Dew," in which the explanation of its formation was given, solving a problem that had long puzzled the philosophers.

Werner, Abraham Gottlob, iii, 131. Born at Wehrau, Upper Lusatia, Sept. 25, 1750; died at Dresden, June 30, 1817. German mineralogist and geologist. He propounded the "Neptunian theory," that "in the beginning all the solids of the earth's present crust were dissolved in the heated waters of a universal sea."

Westinghouse, George, vii, 142. Born at Central Bridge, N. Y., Oct. 6, 1846. American inventor. At the age of fifteen he invented an air-brake, which he continued to improve to meet changing conditions, a modification of this first brake being in use almost universally on steam and electric cars.

Wheatstone, Sir Charles, vi, 178. Born at Gloucester, England, in February, 1802; died at Paris, Oct. 19, 1875. English physicist and inventor. In 1837 he patented a telegraph, an instrument that was supplanted by the invention of Morse. He invented the concertina, the stereoscope, and many improvements in the field of electricity.

Whitney, Eli, ix, 9. Born at Westborough, Mass., Dec. 8, 1765; died at New Haven, Conn., Jan. 8, 1825. The inventor of the cotton-gin—the machine that makes possible the handling and subsequent manufacturing of the great cotton

BIOGRAPHICAL INDEX

crops to-day. Whitney's machines were manufactured by others before he could secure a patent. He made a fortune, however, in manufacturing firearms at Whitneyville, Conn.

Wilkinson, Sir John Gardner, i, 27. Born at Hardendale, Westmoreland, Oct. 5, 1797; died Oct. 29, 1875. English Egyptologist. His writings have furnished important information as to the status of science among the ancient Egyptians.

Wiseman, Richard, ii, 184. Born in 1625; died in 1686. A celebrated English surgeon. He was in the service of all the Stuart kings. He was first to advocate primary amputation in gunshot wounds, and to introduce the treatment of aneurism by compression.

Wohler, Friedrich. (See Liebig and Wohler.)

Wollaston, William Hyde, iv, 41. Born at East Dereham, Norfolk, Aug. 6, 1766; died at London, Dec. 22, 1828. Noted English physicist and chemist. He invented the camera lucida and goniometer, and discovered palladium and rhodium. He also discovered the ultra-violet rays in the solar spectrum.

Wright, Orville, vii, 288. Born at Dayton, Ohio, Aug. 19, 1871. Inventor (with his brother Wilbur), of the aeroplane flying-machine. First tests of flying machine made in 1903, at Kitty Hawk, N. C. Successful long distance tests made near Dayton, Ohio, 1905. With his brother, first demonstrated that the heavier-than-air flying-machine is a practical mechanism.

Wright, Wilbur, vii, 288. Born near Millville, Ind., April 16, 1867. Inventor (with his brother Orville), of the aeroplane flying-machine. Made

KEY AND INDEX

successful flights in 1903; and long distance flights in 1905. In 1908 made numerous flights in Europe, demonstrating the practicality of the heavier-than-air flying-machine, while his brother Orville was making similar demonstrations in the United States.

Wundt, Wilhelm Max, iv, 268. Born at Neckarau, Baden, Aug. 16, 1832. Celebrated German physiologist and psychologist. In 1878 he opened his laboratory of physiological psychology at the University of Leipsic, and established the new psychology on a firm scientific basis.

Xenophanes, i, 114. Born at Colophon, Asia Minor, about 570 B.C.; died about 480 B.C. Greek philosopher, founder of the Eleatic school. He opposed the conception of an anthropomorphic god.

Young, Thomas, iii, 218. Born at Milverton, Somerset, England, June 13, 1773; died at London, May 10, 1829. Celebrated physicist, and general scholar. His discovery of the law of the interference of light was directly responsible for the establishment of the undulatory theory of light. His investigations of the Egyptian hieroglyphics led to their final decipherment. And his theory of color-sensation was afterward developed by Helmholtz.

ENCYCLOPÆDIC GENERAL INDEX

(This Index brings together, under one alphabet, all the important technical terms and the most prominent names of men in all departments of science, theoretical and applied. It does not ordinarily define terms, nor does it aim to give biographical data except insofar as these are necessary to make the reference specific. Its purpose is to analyze the text in a manner at once detailed and comprehensive, with the sole object of guiding the reader to the text itself. Nevertheless, the references are so phrased as to convey, first and last, an enormous amount of information.

The figures in heavy type refer to volumes; those in ordinary type to pages.

For concise definition of terms see the Technical Index and Glossary; for Biographical data see the Biographical Index, both in the present volume.)

ABD-EL-LETIF, Arabian physician, **2**, 21.

Abel, Sir F., experiments with cordite for obtaining high temperature, **6**, 315.

Abruzzi, Duke of, his efforts to find the pole, **7**, 48.

Absolute zero, approach to the, made by liquefying hydrogen, **5**, 69; probable form of all matter at, **5**, 70; quest of, **5**, 72.

Academia Naturæ Curiosorum, founded in Germany, **2**, 201.

Accademia del Cimento, **2**, 200.

Acetylene Gas, the introduction of, **6**, 212 (see also Gas, illuminating).

Adams, Isaac, a printing press invented by, **8**, 122.

Adams, John Couch, predicted the discovery of the planet Neptune, and independently calculated its position, **3**, 42; discovers an error in Laplace's calculation about the moon, **3**, 48.

Aeroplane (see also Navigating the Air), the triumph of the,

Chapter X, **7**, 272; Langley's early experiments and discoveries, **7**, 275; experiments in soaring, **7**, 277; the flying machine of Lilienthal, **7**, 279; the flying machines of Maxim and Langley, **7**, 283; Langley's description of his machine called the "aerodrome," **7**, 284; the practical flying-machine invented by Wilbur and Orville Wright, **7**, 288; the successful flight of Henry Farman, **7**, 293; a series of flights by Wilbur and Orville Wright, **7**, 293; Latham's attempt to fly across the English Channel, **7**, 294; Bleriot's successful flight, **7**, 294; the remarkable flight of Charles R. Rolls, **7**, 294; flights made by Orville Wright near Washington, and at Berlin the same year, **7**, 295; Wilbur Wright's flight up the Hudson, **7**, 295; Paulhan's successful flight from London to Manchester, **7**, 296; Curtiss' flight from

KEY AND INDEX

- Albany to New York, **7**, 297; cross-country flight by officers of the French Army, **7**, 298; Hamilton's flight from New York to Philadelphia and return, **7**, 298; Brookins' altitude record, **7**, 299; all honor due the Wright brothers, **7**, 300.
- Aëtius, Byzantine physician, **2**, 31.
- Agamemnon, detailed by the English Government to lay the first Atlantic cable, **8**, 34.
- Agassiz, Louis, his development of the glacial theory, **3**, 147; his famous *Études sur les Glaciers*, **3**, 154.
- Age, Rough Stone, **6**, 8; Smooth or Polished, **6**, 9; Bronze, **6**, 9; Iron, **6**, 9; of Steam, **6**, 15; of Electricity, **6**, 15.
- Agriculture, methods at beginning nineteenth century compared with those at end, **6**, 19.
- Air (see Atmosphere), experiments with, in the seventeenth century **4**, 6; liquefied, **5**, 45; earliest use of as motive power, **6**, 62; properties of, study by mechanical philosophers, **6**, 63.
- Air-pump invented by Von Guericke, **2**, 211.
- Airy, Sir G. B., his use of permanent magnets to effect compensation for deviation of the compass, **7**, 11; scepticism regarding a transatlantic cable, **8**, 34.
- Albategnius, astronomer, **2**, 15.
- Albucasis, Arabian writer on surgery, **2**, 25.
- Alchemy, **2**, 124; the four elements, **2**, 129; "killing" and "reviving" metals, **2**, 130; Rosicrucians, **2**, 136; Aurea-crucians, **2**, 136; tricks of alchemists, **2**, 138; useful discoveries of alchemists, **2**, 140.
- Alchemy and Astrology—two Pseudo Sciences, Chapter VI, **2**, 124.
- Alcmæon, the first Greek anatomist, **1**, 171; his explanation of the sense of hearing, **1**, 172; his theories concerning the heart and brain, **1**, 126.
- Alexandre, telegraph of, **8**, 9.
- Alexandrian or Hellenistic Period, Greek Science of the, Chapter IX, **1**, 189.
- Alexandrian library not burned by Arabs, **2**, 11.
- Alexandrian science adds a day to every fourth year, **1**, 36.
- Alfonso X., Alfonsine tables, **2**, 17.
- Alhazen, Arabian scientist, **2**, 18; calculates height of atmosphere, **2**, 19.
- Allen, Richard N., credited with the invention of paper car wheels, **8**, 180.
- Almagest* translated into Arabic, **2**, 9.
- Alphabet, the development of the, Chapter IV, **1**, 86; introduction of letters, **1**, 87; Egyptian and Assyrian characters, *ibid.*; first steps in picture-writing, **1**, 89; Egyptian writing, **1**, 90; Babylonian writing, **1**, 93; achievement of, **1**, 98; extension and perfection of, **1**, 101.
- Aluminum, method of producing by the electrolytic process, **6**, 300.
- Alyattus, king of the Lydians, **1**, 103.
- Amélineau, a student of the phonetic value of Egyptian symbols, **1**, 28.
- Amici, Giovanni, constructs a reflecting microscope, **4**, 112; introduced the improved microscope, **4**, 113.
- Amos (with Bright) devised a self-releasing brake for use in cable-laying, **8**, 37.
- Ampère, André Marie, discovered the principles of the science of electro-dynamics, **3**, 239; and the law of combinations of volumes, **4**, 43; paved the way for the study

GENERAL INDEX

- of organic substances, **4**, 55;
his experiments in electro-
magnetism, **6**, 176.
- Anæsthetics, use of, in the dark
age, **2**, 35.
- Anæsthetic power of chloro-
form and ether, **4**, 217.
- Anatomy and physiology in the
eighteenth century, Chapter
IV, **4**, 73.
- Anatomy and physiology in the
nineteenth century V, **4**, 102.
- Anaxagoras, banished from
Greece, **1**, 141; his theories
about the sun and the planets,
1, 143; alleged prediction of
the fall of the famous meteor
at *Ægespotomi*, **1**, 144; his
explanation of the origin of the
heavenly bodies, **1**, 145; a
clear conception of the idea of
universal gravitation, **1**, 146;
the first to explain the phases
of the moon, **1**, 147; his
theory of the Milky Way, **1**,
150; "the father of meteor-
ology," **1**, 151; his specula-
tions concerning thunder and
lightning, **1**, 152; his idea
that fishes respire air through
their gills, "attracting" it
through water, **1**, 153; his
speculations as to natural
objects, **1**, 154; he claimed
that every unit or atom in
nature was unchangeable and
indestructible, **1**, 155; the
distinction between molecu-
lar processes and atomic
processes, **1**, 158; *nous*, the
omnipotent artificer of the
material universe, **1**, 159;
the most farseeing scientific
imagination of pre-Socratic
antiquity, **1**, 161; the founder
of the atomic theory, **1**, 169;
he took account of the hypo-
thetical counter-earth in his
explanation of the eclipses,
1, 216; conceived the idea of
universal gravitation before
Newton, **2**, 236.
- Anaximander, inventor of the
sun-dial, **1**, 109; his concep-
tion of the form of the earth,
1, 110; the first teacher of
organic evolution, **1**, 111.
- Anaximenes, assisted in perfect-
ing the sun-dial, **1**, 109.
- Animal kingdom, new classifica-
tion of, by Cuvier, **4**, 102.
- Animals, domestic, man's use
of, in the conquest of nature,
6, 59.
- Animists' system, theory of, **4**,
185.
- Anschütz, his interest in the
development of chrono-pho-
tography, **8**, 250.
- Anthrax, cause of, **4**, 227, 228;
sheep and cattle given im-
munity from, at the Pasteur
Institute, **5**, 185.
- Anthropology, problems in, **5**,
228; its position to-day, **5**,
229.
- Antipater, his epigram showing
that windmills existed in the
time of Augustus, **6**, 71.
- Anti-rabic treatment given at
the Pasteur Institute, **5**, 183.
- Antisepsis, Lister's discovery of,
4, 229.
- Arabian hospitals, **2**, 26.
- Arabian learning, its subjects,
2, 13; mathematics, **2**, 14;
astronomy, **2**, 14-17; optics,
2, 18; chemistry, **2**, 20; medi-
cine, **2**, 21.
- Arabian method of earth-meas-
urement, **2**, 14.
- Arabian numerals, period of
their invention, **2**, 13.
- Arabians, Mediæval Science
Among the, Chapter II, **2**,
13.
- Arabic translations, **2**, 9.
- Arago, Dominique François, a
convert to Fresnel's wave
theory, **3**, 226; demonstrated
that electricity not only in-
fluenced a magnet, but ac-
tually produced magnetism,
3, 239; constructed a device
in which a metal disk was
made to revolve in the pres-
ence of a current of electricity,
6, 176.

KEY AND INDEX

- Arban, M.**, his record flight in a balloon, **7**, 256.
- Arcadius**, public windmills appeared in Rome about the time of this ruler, **6**, 71.
- Archæology**, *The New Science of Oriental*, Chapter X, **4**, 287.
- Archer, Frederick Scott**, invented the collodion plate, **8**, 230.
- Archimedes**, invented many mechanical contrivances, **1**, 197; the Archimedian screw, *ibid.*; his devices for the defence of Syracuse, **1**, 108; his combination of multiple pulleys, **1**, 200; his invention of the catapult, **1**, 201; his contrivance for wrecking galleys, **1**, 202; **6**, 34; the mythical legend of the burning-glass, **1**, 205; his studies of the properties of the lever, **1**, 206; his experiment with King Hiero's crown, **1**, 207; his demonstrations of the buoyancy of water, **1**, 208; the problem of the triangle and a circle, **1**, 209; his crude conception of the idea of logarithms, **1**, 210; his assumption about the size of the sun and earth, *ibid.*; his computation about the number of grains of sand that would be required to cover the sphere of the sun's orbit, **1**, 211; recorded laws of the lever, realized possibilities of, **6**, 30; classical remark regarding moving of world, **6**, 31.
- Argand, Aimé**, his invention of the oil lamp with a circular wick, **6**, 205.
- Argon**, discovery of, **5**, 85, 86.
- Argus**, the attack on, by Fulton's submarine, **7**, 101.
- Aristarchus**, of antiquity, **1**, 218, 220, 221.
- Aristotle**, his name a synonym for Greek science a thousand years after his death, **1**, 182; his acceptance of the doctrine of his spherical figure of the earth, **1**, 183; a pathfinder in the science of zoology, **1**, 185; his divisions of the vertebrates and invertebrates are accepted by every one to-day, **1**, 186; his classification of blood-bearing animals and fishes not far afield from modern divisions, **1**, 187; considered manual toil degrading, **6**, 26.
- Arkwright, Sir Richard**, his development of the spinning frame marked the beginning of the new era, **6**, 21; his early life, **9**, 26; aided by a Mr. Strutt he interests capitalists in his invention, **9**, 27; capitalists combine to defraud him of his patents, **9**, 28; court decision finally rendered against him, **9**, 30; traits in his character, **9**, 31.
- Armature**, see *Dynamo*, **6**, 173.
- Armature, ring**, invented by the Italian, Picnotti, **6**, 179; re-invented by Gramme, **6**, 179.
- Armstrong, Lord**, his water motor, **6**, 121.
- Arnald of Villanova**, physician, **2**, 34.
- Artificial Gems**, **9**, 327.
- Artificial Stone, or Concrete**, Chapter VIII, **9**, 182.
- Artificial Stone, or Concrete**, the manufacture of, **9**, 182; concrete blocks, **9**, 184; mixing the materials, **9**, 187; molding the blocks, **9**, 189; utility and beauty, **9**, 193; reinforced concrete construction, **9**, 195; advantages of reinforced concrete, **9**, 197; strength and durability of concrete, **9**, 201; the reinforcing skeleton of metal, **9**, 204; a modern building, **9**, 205.
- Arzachel**, "trepidation of the fixed stars," **2**, 16.
- Assyria**, *Science of Babylonia and*, Chapter III, **1**, 56.

GENERAL INDEX

- Assyrian month, 1, 64; sabbatical days, 1, 65.
- Assyrian scripture, restoration of, 4, 293.
- Assyrio-Babylonian records, of greater historical accuracy than the Egyptian, 1, 59; the discrepancy between the Babylonian and Egyptian years, 1, 65; tablets dealing with magic make up a large proportion of, 1, 70.
- Astrolabe, invented by Joseph and Roderick, and Martin de Bohemia, 7, 19.
- Astrologers, in Babylon they were men of high rank and their office was hereditary, 1, 67; gave their chief attention to the moon, 1, 68.
- Astrology, Two Pseudo Sciences—Alchemy and, Chapter VI, 2, 124.
- Astrology, present-day survival, 2, 144; predictions of Lilly, 2, 145; George Wharton, 2, 150; other alleged predictions, 2, 152, 155; cause of the decline of astrology, 2, 155.
- Astronomer priests, their duty was to predict the rising of the Nile, 1, 39.
- Astronomy, The Successors of Newton in, Chapter I, 3, 3.
- Astronomy, The Progress of Modern, Chapter II, 3, 19.
- Asurbanipal, king of Assyria, his contribution of tablets, 1, 67; the great library of, in the British Museum, 4, 295.
- Athens, Post-Socratic Science at, Chapter VIII, 1, 178.
- Atherstone, Dr., a mineralogist of Grahamstown who first suspected that stones found in South Africa were diamonds, 9, 316.
- Atlantic Cable, company formed for the laying of, 8, 33; success in a large measure due to Lord Kelvin, 8, 33; Sir G. B. Airy declared that such means of communication was impossible, 8, 34; the *Agamemnon* and the *Niagara* undertake to lay the first cable, 8, 34; cable breaks, 8, 36, second attempt made by the same ships, 8, 38; cable again breaks, 8, 39; success at last, 8, 39; improved methods and new cables, 8, 40; the cable of '65, 8, 41; the *Great Eastern* pressed into service, 8, 42; cost of gutta-percha used the most expensive single item of expense, 8, 43; instrumental aids, 8, 45.
- Atmosphere, constituents of, 5, 89; pressure and weight of, shown by Torricelli and Boyle, 6, 65; Boyle and Mariotte's law, 6, 66; pressure of, shown by experiment with Magdeburg spheres, 6, 66; why human body can support pressure of, 6, 67; use of by windmills, 6, 68.
- Atom, the vortex, speculation about, 5, 216; proof of the existence of, 5, 217; its relation to the electron, 6, 166.
- Atomic weights, 4, 64-67; curious relations between, of various elements, 4, 66; their relations with other characteristics, 4, 67.
- Atoms, affinity of, 5, 218; space relations of, 5, 219.
- Attic Period, Greek Science in the Early, Chapter VII, 1, 139.
- Aurora borealis, the, Franklin's explanation of, 3, 173; Erasmus Darwin's theory of, *ibid.*; Biot's theory of, 3, 174; sun spots linked with, 3, 175.
- Automatic Couplings, 7, 147.
- Automatic telephone systems, 8, 87.
- Automobile, the coming of the, 7, 156; Cugnot's automobile, 7, 158; the automobile of William Murdoch, 7, 158; Trevithick's automobile, 7, 159; the attitude of the public toward the steam automobile invented by Mr. Gurney,

KEY AND INDEX

- 7, 160; an extraordinary piece of legislation, 7, 161; real progress of the automobile due to the oil engine, 7, 163; scientific aspects of automobile racing, 7, 164; some records made at Ormond, 7, 165; records made by Oldfield, 7, 166; comparative speeds of various vehicles and animals, 7, 167; a miraculous transformation of energy, 7, 170.
- Avenzoar, Arabian physician, 2, 26.
- Averrhoës, commentator of Aristotle, 2, 10, 26.
- Avicenna, Arabian "Prince of Physicians," 2, 24.
- Avogadro, Amadeo, 4, 43; law of, 4, 57.
- Axe, modified form of lever, 6, 58.
- BABYLON, its fame at its height in the time of Herodotus, 1, 57; in Babylonian science we have the Eastern mind at its best, 1, 61.
- Babylonia and Assyria, Science of, Chapter III, 1, 56.
- Babylonian astronomy, 1, 61, 62; adjustment of the calendar, 1, 63.
- Babylonian medicine, the practitioner of, occupied a position of authority, 1, 75; his emoluments and penalties, 1, 76.
- Babylonian science, estimates of, 1, 77; Canon Rawlinson on, 1, 82; spelled superstition, 1, 85.
- Bachelder, John, improves Howe's sewing machine, 9, 96.
- Bacon, Francis, influence on science, 2, 192; indirectly a founder of the Royal Society, 2, 201.
- Bacon, Roger, 2, 44; his use of lenses, 2, 45; supposed invention of gunpowder, 2, 46; estimate of his work, 2, 46.
- Bacqueville, Marquis de, his attempt at aerial flight, 7, 229.
- Bacteria, discovery of, 2, 179; their relation to fermentation and to disease, 4, 218.
- Baeyer, produced indigo commercially, 8, 313.
- Baglivi, Giorgio, distinguished in medicine, 4, 182.
- Barlow, suggested that compensation for deviation of the compass be effected by the adjustment of bodies of iron, 7, 11.
- Barnett, William, suggested compressing explosive mixture in cylinder of gas engine before exploding it, 6, 138.
- Barometer, mercurial, invented by Torricelli, 2, 122; statical, invented by Boyle, 2, 205.
- Bastian, Professor, revived the claims of Pouchet, 4, 180.
- Bay of Naples, the, fauna of, 5, 124; abundance of material for biological study found in, 5, 125; uses made of specimens found in, in scientific study, 5, 128.
- Bayley, Dr., expert in spectroscopy, 5, 83.
- Beard, Thomas, shoemaker who came on the *Mayflower*, 9, 108.
- Becquerel, Alexandre Edmond, the first to take up specifically the matter of color-photography, 8, 235.
- Becquerel, M. Henri, discovery of a radio-active substance, 5, 98; "rays," 5, 100; 8, 220.
- Beginnings of Greek Science, The, Chapter V, 1, 103.
- Beginnings of Modern Chemistry, The, Chapter II, 4, 11.
- Behring's discovery of tetanus and diphtheria antitoxine, 4, 242.
- Belisarius, constructed floating mills upon the Tiber, 6, 71.
- Bell, Prof. Alexander Graham, made tests of Professor Trowbridge's instrument for transatlantic communication, 8, 50; invents a practical tele-

GENERAL INDEX

- phone, **8**, 73; describes his invention, **8**, 74; controversy with Gray, **8**, 81.
- Bell, Dr. (Sir Charles), discovery of motor and sensory nerves, **4**, 249.
- Bell, Rev. Patrick, his design for rotary engine described, **6**, 121.
- Bell, electric, mechanism of operation, **6**, 164.
- Belshazzar, mythical king of Babylon whose name was probably confounded with that of the warrior son of King Nabonidus, **8**, 106.
- Bensley, assisted Koenig in the practical solution of the problem of the cylinder press, **8**, 123.
- Berlin Institute of Hygiene, the, **5**, 193-202; work of Professor Koch in, **5**, 194; work of his successors in, **5**, 195; department of bacteriology in, **5**, 196; investigations of the functions of the human body in, **5**, 197; models in the Museum of Hygiene, **5**, 198, 200; studies in problems of ventilation, **5**, 200.
- Berlin Institute of Pathology, the, **5**, 186-193; study of diseases in, **5**, 187; studies of organic action and cellular activities in, **5**, 188; Virchow's methods of teaching in, **5**, 191, 192.
- Berlin system of sewage-disposal, the, **5**, 199.
- Berliner, Emil, invented what is known as a microphone transmitter, **8**, 83.
- Bernard, Claude, studies of the ductless glands, **4**, 137; discovers that the blood undergoes a change in passing through the liver, **4**, 138; discovers that the sympathetic nerves regulate the blood supply, **4**, 259; his discovery of inhibitory nerves, **4**, 261.
- Berosus, a Babylonian historian, **1**, 58.
- Berthez, Paul Joseph, champion of the Vitalists' system, **4**, 185.
- Berthollet, his refusal to accept the atomic theory, **4**, 41.
- Berzelius, Johan Jakob, accepts Dalton's theory, **4**, 41-44; his binary theory, **4**, 53; his dualistic theory, **4**, 55; coined the word "isomerism," **4**, 62.
- Besnier, the flying machine of, **7**, 228.
- Bessel, predicted the existence of the planet Neptune, **3**, 42; measured the parallax of a star in 1838, **3**, 60.
- Bessemer, Sir Henry, **6**, 291; his discovery of the process of converting cast-iron into steel, **6**, 292; the "Bessemer-Mushet" process of making steel, **6**, 293; his costly experiments with the gyroscope, **7**, 218.
- Bianco, Signor Lo, chief of the collecting department of the Marine Biological Laboratory, **5**, 122.
- Bichat, Marie François, studies of the animal and organic systems of vertebrates, **4**, 107; his division of anatomical structures into sets of tissues, **4**, 108.
- Bicycle, application of lever-principle to, **6**, 36; the development of the, **7**, 154; the earliest bicycle introduced by Baron von Drais, **7**, 154; the treadle-bicycle invented by Kirkpatrick MacMillan, **7**, 155; the pneumatic tire introduced, **7**, 155; the safety bicycle **7**, 156; its popularity and its sudden abandonment, **7**, 156.
- Biological Laboratory at Naples, The Marine, Chapter V, **5**, 113.
- "Biology," word coined independently by Treviranus and Lamarck, **4**, 160.
- Biot, Jean Baptiste, investigated the meteor of 1803, **3**, 168; accounted for it on scientific grounds, **3**, 169.

KEY AND INDEX

- Birch, a student of Egyptian writing, 1, 27.
- Birkeland, Christian, discoverer of a method for obtaining nitrogen from the air, 6, 306.
- Black, Dr. Joseph, his latent heat observations on the subject of precipitation of vapor, 3, 184; disproved by Dr. Wells, 3, 185; continues Hale's study of the elasticity of air, 4, 11; discovery of the properties of carbonic-acid gas, 4, 12; studies continued by Cavendish, *ibid.*; probable participation in the development of Watt's ideas, 6, 94; his experiments with balloons, 7, 230.
- Blackett, his experiments with steam locomotives, 7, 123.
- Blackwell, F. O., quoted as to the efficiency of the electric motor, 6, 262.
- Blaew, William, printing press improved by, 8, 122.
- Blake, Dr. Clarence J., suggested the use of the human ear itself as a phonautograph, 8, 79.
- Blake, Francis, inventor of a telephone transmitter, 8, 84.
- Blanchard, Jean-Pierre, his attempt to produce a dirigible balloon, 7, 238.
- Blanquart, glass negatives improved by, 8, 229.
- Blast-furnace, 6, 284; old and new types of, 6, 285.
- Blériot, Louis, his successful flight across the English Channel, 7, 294.
- Blood corpuscles, functions of, 4, 135; important rôle played by, 4, 136.
- Boats, the use of sails for propelling, 7, 56; steering with oars, 7, 56; the invention of the rudder, 7, 56; type of boats used by the Greeks, 7, 57; vessels of the Romans, 7, 57; boats constructed by the Norsemen, 7, 58; mediæval ships, 7, 59; modern sailing ships, 7, 60; early attempts to invent a steam-boat, 7, 63; Fulton's *Clermont*, 7, 64; screw-propeller boat invented by Stevens, 7, 68; sea-going steamships, 7, 73; ships built of iron and steel, 7, 74; the use of turbine engines on boats, 7, 82; the adoption of liquid fuel on boats, 7, 90.
- Boerhaave, Hermann, fame of, 4, 182; his classification of the different branches of medicine, 4, 183; his doctrines arranged into a "system" by Hoffmann, 4, 184.
- Bolton, one of the inventors of the collodion-emulsion process, 8, 231.
- Bond, W. C., discoverer of the inner or crape ring of Saturn, 3, 44.
- Books, preservation of ancient, 2, 6; comparative number of, issued in the age of Pericles, 6, 13.
- Bookbinding, the development of, 8, 153.
- Borelli, "On the Motive of Animals," 2, 188.
- Boscovich, Roger Joseph, the ultimate constitution of matter as conceived by, 3, 293.
- Bose, George Matthias, inventor of an electric machine, 2, 274; explanation of aurora borealis, 2, 277.
- Botta, his excavations at the site of old Nineveh first brought tablet books to the eye of modern scholarship, 8, 103.
- Boulevard Pasteur, the, 5, 179.
- Boulton, Matthew, associated with Watt to found the most famous of early steam-engine companies, 6, 100.
- Bourseul, Charles, suggests an electrical telephone, 8, 71.
- Bowden, H. L., the automobile record established by, in 1905, 7, 164.

GENERAL INDEX

- Boyle, Robert, 2, 204; experiments on air, 2, 205; calculation of atmospheric pressure, 2, 206; 6, 65; views on color, 2, 208; work in electricity, 2, 209; his theories as to the composition of the atmosphere, 4, 4-6.
- Boyle's law, developed independently by Mariotte, 6, 66.
- Bradley, Dr. James, discovers the libratory motion of the earth's axis, 3, 12.
- Bradley, in association with Lovejoy, conducted experiments at Niagara Falls designed to extract nitrogen from the air, 6, 306.
- Brahe, Tycho, a celebrated astronomer who declined to accept the heliocentric idea concerning the earth, 1, 217.
- Braid, Dr. James, investigation of the phenomena of hypnotism, 4, 269.
- Brain, studies of the, 4, 245-249, 270-286; localization of centres, 4, 272-274; minute structures of the, 4, 276-286.
- Branca, Giovanni, first to propose turbine engine, 6, 87.
- Branly, Dr., invented a "coherer" for detecting the presence of Hertzian waves, 8, 52.
- Brennan, Louis, his invention of the gyrocar, 7, 195.
- Brett, John W., his connection with the laying of the Atlantic cable, 8, 30.
- Brewster, Dr. David, suggestions to improve the microscope, 4, 110.
- Bright, Sir Charles, his connection with the laying of the Atlantic cable, 8, 30.
- Britannia*, the first steamer of the Cunard Line, 7, 74.
- British Museum, The, Chapter 1, 5, 3.
- British museum, the, founding of, 5, 3; Sloan's collection purchased for, 5, 4; acquisition of Hamilton's treasures for, 5, 5; Egyptian antiquities for, *ibid.*; erection of present building, 5, 6; statue of Darwin in, 5, 9; arrangement of specimens in, 5, 10, 11; public interest in, 5, 12.
- Broca, Dr. Paul, and localization of speech, 4, 272.
- Bronze Age, advance of civilization in, 6, 9.
- Brookins, W. H., altitude record made by, 7, 299.
- Brown, Robert, discovery of the nuclei of plant cells, 4, 115.
- Brown, Samuel, introduced a vacuum gas engine for raising water by atmospheric pressure, 6, 135.
- Bruce, Robert, his traditional perseverance compared to that of the heroes who laid the Atlantic cable, 8, 30.
- Brugsch, an Egyptologist, 1, 28.
- "Brunonian" system, 4, 187.
- Brunton, the remarkable locomotive constructed by, 7, 123.
- Brush, Charles F., his invention of an arc light, 6, 226.
- Buckett, introduced a gas engine based on Cayley's invention, 6, 133.
- Buffon and the transmutation of species, 4, 149.
- Bull (in connection with Trevithick) made direct-acting pumping engines with an inverted cylinder, fixed in line with the pump rod, and actually dispensing with the beam, 6, 113.
- Bunsen, with Kirchhoff, perfected the spectroscope, 4, 69.
- Burnham, S. W., discovers one thousand new clusters of stars, 3, 59.
- Burrows, Stephen, credited with the discovery that the magnetized needle shifts its direction, 7, 9.
- Bushnell, David, first practical submarine boat made by, 7, 94.
- Butler, quoted as to the strength of a web of heavy paper

KEY AND INDEX

- when superheated and then cooled on the dryers, 8, 170.
- CABLE** Systems, 7, 177.
- Calcium carbide, method of its manufacture at Niagara Falls, 6, 214.
- Callixenos describes a ship said to have been used by Ptolemy Philopater, 7, 57.
- Calmette, discoverer of the serum treatment for serpent-poisoning, 5, 184.
- Calotype process, invented by Talbot, 8, 227.
- Calvin withholds the document of Servetus, 2, 168.
- Candle, tallow, invented in the twelfth century, 6, 203.
- Canton, John, produces both positive and negative electricity on the same substance, 2, 295.
- Carbonic-acid gasliquefied, 5, 40.
- Carcel, his improvement of Quinquet's oil lamp, 6, 205.
- Carlisle, discovered that a galvanic current would decompose chemicals in solution, 8, 11.
- Carmania*, equipped with turbine engines in a test for speed with the *Caronia*, equipped with reciprocating engines, proved herself the better boat, 7, 82.
- Carnegie*, an American ship constructed for the purpose of making accurate charts of the lines of magnetic declination in various parts of the globe, 7, 12.
- Carnot, Sadi, demonstrated that a definite quantity of work could be transformed into a definite quantity of heat, 3, 255; worked out general theory of the heat engine, 6, 115.
- Caro, associated with Frank in process for fixation of nitrogen, 6, 309.
- Caronia*, equipped with reciprocating engines for a test against the *Carmania* equipped with turbine engines, 7, 82.
- Carpenter, William B., studies in embryology, 4, 122.
- Cartwright, Dr. Edmund, clergyman of the Church of England, and inventor of the power-loom, 9, 44; as poet and preacher, 9, 44; as inventor of the power-loom, and other useful devices, 9, 45.
- Carré, his invention of carbons for arc lights, 6, 227.
- Cassini, Dominic, a celebrated French astronomer, 3, 13.
- Catara, Galeazzo, records the building of the first chimney in a house in Rome in the fourteenth century, 9, 150.
- Cathode rays, Sir William Crookes experiments with, 3, 249; Professor Roentgen's discovery of the remarkable effects of, 3, 251-252.
- Cattle-raising, methods at beginning nineteenth century compared with those at end, 6, 20.
- Caus, Solomon de, makes practical application of della Porta's idea for pumping by steam, 6, 83.
- Cavallo, Tiberius, demonstrated the possibility of making toy balloons, 7, 230.
- Cave-dwellers, the, 9, 134.
- Cavendish, Henry, continued Black's studies, 4, 13; discovery that water is formed by the combination of hydrogen and oxygen, 4, 14; controversy with Watt, *ibid.*, experiments with air, 4, 16; discovery of nitrous acid, 4, 17; discovery of hydrogen gas and its effect upon aeronautics, 7, 230.
- Cawley, John, English plumber and glazier associated with Newcomen in patenting atmospheric engine, 6, 89.
- Cayley, Sir G., gas engine motor invented by, 6, 132.

GENERAL INDEX

- "Cedar of Lebanon," the, **4**, 292.
- Ceilings of ancient dwellings, **9**, 154.
- Celestine III., Pope, decided that tithes of the mediæval wind-mills belonged to the clergy, **6**, 69.
- Cell contents, studies in, by Von Mohl, **4**, 123; observed by Corti in 1774, **4**, 124; rediscovered by Treviranus in 1807, *ibid.*; filled with fluid called "sarcode," **4**, 124.
- Cell theory, Schwann and Schleiden and the, **4**, 118-122; foreshadowed by Wolff and Treviranus, **4**, 122; elaborated, **4**, 122-128.
- Cell, voltaic, **6**, 163; action of, **6**, 163.
- Cell walls of vegetables, Payen and, **4**, 124.
- Cellini, Benvenuto, records an attempt to poison him by diamond dust in his salad, **9**, 296.
- Cells, essential structure of living organism, **4**, 129; principles of mechanical construction of, **5**, 225.
- Celsus, Cornelius, his manuscript found in the fifteenth century, **2**, 40.
- Centrosome, discovered by Van Beneden, **5**, 226.
- Chabas, a student of Egyptology, **1**, 28.
- Chaldean, a name once synonymous with magician, **1**, 66.
- Chaldean magic, tablets relating to, **1**, 70; symbolism of the black and white cloth, **1**, 71; song of the seven spirits, **1**, 72; exorcisms to ward off disease, **1**, 73; birth portents, *ibid.*; omens furnished by dogs, **1**, 74.
- Chambers, Robert, his *Vestiges of the Natural History of Creation*, **4**, 161; quotation from, **4**, 162-164.
- Champollion, Jean François, a famous student of the science of Egyptology, **1**, 27; decipherment of the Rosetta Stone, **4**, 290.
- Chandler, Professor, his address before the "Society of Electro-Chemistry," **6**, 298.
- Chapman, the cable road of, **7**, 123.
- Charcot, Dr., on the phenomena of hypnotism, **4**, 269.
- Charles II., his attempt to change the fashion of his time, **9**, 62.
- Charles V. accepted cotton garments made by the Aztecs as gifts suitable for the monarch, **9**, 7.
- Charlotte Dundas, constructed by Symington to be used as a towing vessel, **7**, 67.
- Charms and incantations, **1**, 46-51; effect of a lock of hair or nail parings incorporated in a waxen figure, **1**, 46; the magical spell of enemies the source of all human ailments, **1**, 47; efficacy of a beetle as a medicinal agent, **1**, 48.
- Charpentier, the secret of his superior pottery, **9**, 232.
- Chaucer, Geoffrey, a chance reference in a poem proves that the points of the compass had been established before his day, **7**, 9.
- Chemical affinity, **4**, 57-64; theory of digestion, **4**, 88.
- Chemistry, the phlogiston theory in, **4**, 3-10; at the beginning of the eighteenth century, **4**, 11; Lavoisier and the foundation of modern, **4**, 28; since the time of Dalton, **4**, 38-72; organic, **4**, 53-56; foremost workers in, **4**, 55.
- Chemistry Since the Time of Dalton, Chapter III, **4**, 38.
- Chemistry, The Beginnings of Modern, Chapter II, **4**, 11.
- Chemistry, The Phlogiston Theory in, Chapter I, **4**, 3.
- Chéron, M. André, three-lens camera devised by, **8**, 240; process of color-photography improved by, **8**, 240.

KEY AND INDEX

- Chicken cholera, Pasteur's experiments with, 4, 232.
- Chimneys, the first, 9, 151.
- China, the making of, 9, 260.
- Chisel, modified form of lever, 6, 57.
- Chloroform, pain-dispelling power of, discovered by Simpson, 4, 217.
- Cholera, researches in the prevention and cure of, 5, 184.
- Choke Damp, in mines, 6, 248.
- Christian medical science, 2, 29.
- Christy, Henry, his discovery in the caves of Dordogne, 3, 104; presumptive evidence that man and the mammoth had been contemporaries, 3, 105.
- Chromosomes, the study of, 5, 133; Professor Weismann's theory of heredity based on, 5, 134.
- Chronometer, perfecting the, 7, 23; finding the time without a chronometer, 7, 28.
- Chrono-photography — Moving Pictures, the development of, 8, 248.
- Chrysostom, Saint John, his silence regarding windmills makes it doubtful whether they existed in his day, 6, 68.
- "Circuit," electrical term coined by Watson, 2, 285.
- City of Paris* (now the *Philadelphia*) one of the first twin-screw boats, 7, 81.
- Civilization, primitive man's struggles toward, 9, 1-4.
- Clamond, his invention of the gas mantle, 6, 209.
- Claremont, Leopold, describes the process of diamond-cutting, 9, 306.
- Clark, Alvan, discovered the dark companion of Sirius, 3, 66.
- Clarke, W. B., his name intimately connected with the early efforts at utilization of magneto-electric power, 6, 178; an interesting use of the electric pump associated with the telephone in connection with mining, noted by, 6, 266.
- Classical Science, A Retrospective Glance at, Chapter XI, 1 (i.e., vol. 1), 285.
- Clausius, Rudolf Julius Emanuel, has a part in perfecting theory of steam-engine, 6, 115.
- Claussen, Peter, inventor of the circular knitting machine, 9, 56.
- Clayton, Rev. Joseph, made experiments in the distillation of coal, producing a gas that was inflammable, 6, 207.
- Clerk-Maxwell, J., he characterized the rings of Saturn as a "shower of brickbats," 3, 44; thought they must consist of disconnected particles, 3, 45; advanced the idea that light waves were really electromagnetic waves, 3, 247; 6, 154; believed that electricity and magnetism were various conditions of stress and motion in the ethereal medium, 3, 280; all interstellar space filled with ether, 3, 283; his study of the kinetic theory of gases, 3, 295; his investigation of the subject of molecular dynamics, 3, 297; his calculations of the distance traversed by molecules between collisions in ordinary air, 3, 298; his attempts to perfect the process of color-printing, 8, 212; his experiments in color-photography, 8, 237.
- Clermont, invented by Fulton, 7, 71; account of its first passage up the Hudson, 7, 72.
- Clock, pendulum, invented by Huygens, 2, 219; marine, invented by Harrison, 2, 257.
- Clothing the Extremities, Chapter V, 9, 103.
- Clothing the Extremities, custom of wearing shoes by primitive man as protection

GENERAL INDEX

- against cold, 9, 103; the shoes of ancient people, 9, 105; fantastic foot-gear of the Middle Ages, 9, 107; the rise of the modern shoe industry, 9, 108; Thomas Beard, shoemaker who came on the *Mayflower*, 9, 108; Philip Kertland established a shoe manufactory at Lynn, in 1636, 9, 108; Massachusetts the center of shoe industry during the Revolutionary War, 9, 109; early methods of shoe manufacture, 9, 110; the wooden shoe peg invented, 1811, 9, 110; application of machinery to shoe-making, 9, 112; the introduction of the McKay sewing-machine, 9, 112; introduction of the Goodyear heeling machine, 9, 113; lasts and patterns, 9, 117; actual process of shoe-making in factories at the present time, 9, 119; gloves and gauntlets, 9, 121; possible origin of the use of gloves, 9, 122; glove-wearing in the Middle Ages, 9, 124; early manufacture of gloves, 9, 125; application of the sewing-machine to glove-making, 9, 128; materials for making gloves, 9, 129; methods of tanning the hides, 9, 130.
- Clymer, an early printer whose presses were of the primitive Gutenberg type, 8, 122.
- Coal-tar colors, 8, 311.
- Cocking, Henry, type of parachute invented by, 7, 245.
- "Coherer," instrument invented by Doctor Branly for detecting the presence of Hertzian waves, 8, 52.
- Cohesion, "force" of, 5, 49.
- Colding, a Danish scientist, and the transformation of heat, 3, 257.
- Cole, Humfray, suggested a means of measuring a ship's rate of progress, 7, 15.
- Cole, Timothy, famous contemporary engraver whose work differs in quality rather than in method from the earliest wood-engraving, 8, 187.
- Cole, championed the cause of Lewis Paul as inventor of the spinning-machine, 9, 22.
- Collodion-emulsion process, invented by Bolton and Sayce, 8, 231.
- Color-photography, the development of, 8, 234; the future of, 8, 247.
- Colton, Dr., associated with Mr. Lilly in the construction and operation of a small model locomotive, 7, 179.
- Columbus, Christopher, effect of his discovery, 2, 50; would not have dared attempt his voyage of discovery without a compass, 7, 9; found cotton growing in most of the lands he discovered, 9, 7.
- Columbus, sixteenth-century anatomist, 2, 166.
- Comets, strangers to our planetary system, 3, 38; their movements not controlled by the general law, 3, 39; eccentric orbits, 3, 51; their spectacular tails, 3, 52, 53; Encke and Biela's discovery of, 3, 54; twenty are controlled by Jupiter and Saturn, *ibid.*; Biela's broken into fragments, 3, 55; Professor Newcombe's estimates of, 3, 56; minor nebulæ drawn into our system, 3, 70.
- Communism as advocated by Pythagoras, 1, 127.
- Compound engine, Woolf's development of, 6, 117; Hornblower's invention of, 6, 117.
- Compound engine—see Steam engine.
- Computations, as to the age of the earth's crust, 5, 210; of the earth's ultimate fate, 5, 212.
- Conquest of the Zones, Chapter I, 7, 5.

KEY AND INDEX

- Conservation of Energy, The, Chapter VIII, 3, 253.
- Constantinople, effect of its capture by the Turks upon contemporary learning, 2, 42.
- Cook, gave great attention to the needle telegraph, 8, 25.
- Cook, Dr. Frederick A., his claims to discovery of the pole, 7, 49; controversy with Peary, 7, 49; his records adjudged inadequate, 7, 49.
- Cook, Captain James, his astronomer discovers that the ship influences the compass, 7, 10.
- Cooper, W., improved the colloidion-emulsion process, 8, 232.
- Cope, Professor, traced the ancestry of the camel, 3, 113.
- Copernicus to Kepler and Galileo—The New Cosmology, Chapter IV, 2, 52.
- Copernicus, Nicholas, famous astronomer, 2, 54; his system, 2, 56; introduction to his book, 2, 57; "On the Order of the Spheres," 2, 60; argument from parallax urged against him, 2, 63; advocates of his theory, *ibid.*
- Copper- and Steel-Plate Engravings, 8, 192.
- Cordite, use of, for producing high temperatures, 6, 315; Sir Andrew Noble and Sir F. Abel's experiments with, 6, 315; possibility of using it for making artificial diamonds, 6, 315.
- Corlis, an early experimenter of the sewing-machine, whose efforts were unknown to Howe, 9, 94.
- Cortez, Hernando, found cotton growing indigenously in Mexico and Peru, 9, 7.
- Corti, Bonaventura, observed motion of the cell contents, 4, 124.
- Corvisart, Jean Nicolas de, physician to the First Consul, 4, 199; lays the foundation of physical diagnosis, 4, 200.
- Cosmology, The New—Copernicus to Kepler and Galileo, Chapter IV, 2, 52.
- Costumes, effect of climate upon, 9, 59; military methods and fashion responsible for, 9, 60; some curious fashions explained, 9, 61; effects of the plagues upon fashions, 9, 62; the age of wigs, 9, 63; the age of the "ruff," 9, 65; knitted garments, 9, 68; some remarkable costumes, 9, 69; fashion versus comfort, 9, 74; the return to the common-sense age in clothing, 9, 76; the wholesale manufacture of clothing, 9, 78; pioneer methods of George Opdyke, 9, 78; the "task system" introduced, 9, 80; the "Boston" or factory system, 9, 81; steam and electricity in factories, 9, 83.
- Cotton, fabrics of, probably first introduced into the West from India, 9, 5; wonderful dexterity of Hindus in weaving, 9, 6; laws passed in Great Britain to prevent importation of, 9, 6; India as the sower of, 9, 6; Western Hemisphere as source of supply, 9, 8; value of the crop raised in the two Americas, 9, 8; preparing for shipment, 9, 12; varieties of, 9, 13; various machines for opening the bales and preparing the fibres for spinning, 9, 14; carding-machine invented by James Hargreaves, 9, 16.
- Cotton-Gin, invented by Eli Whitney, 9, 8; circumstances leading to the invention of, 9, 10; mechanism of Whitney's gin, 9, 11.
- Count de la Vaux, his record flight in a balloon, 7, 256.
- Cowper, E. A., introduced the suspension wheel as an im-

GENERAL INDEX

- provement to the bicycle, **7**, 155.
- Cow-pox, **4**, 194, 195; persons afflicted with, secure from small-pox, **4**, 196.
- Coxwell, the record flight of one of his balloons, **7**, 256.
- Crane, use in antiquity, modern crane, **6**, 38; combines principle of lever and inclined plane, **6**, 39.
- Croll, Dr., computes that the Gulf Stream conveys to the North Atlantic one-fourth the heat which it receives from the sun, **3**, 197; it is produced by the actual trade-winds, **3**, 198; the effect on the climate of Europe should its course be deflected, *ibid.*
- Crompton, Samuel, inventor of the spinning-machine called "the mule," **9**, 32; early life and events leading up to his invention, **9**, 32; the scant recompense he received for his great invention, **9**, 34.
- Crookes, Sir William, experiments with the cathode rays, **3**, 249; and radio-active substances, **5**, 103; his spinthariscopes, **5**, 104; his experiments showed that nitrogen in the atmosphere can be made to combine with oxygen, **6**, 306.
- Cros, Charles, described a way in which an instrument might be made that would produce such sounds as the human voice, **8**, 94.
- Cross-staff, the crudest form of apparatus for measuring the height of the sun and stars, **7**, 19.
- Crotonian School of Philosophy, founded by Pythagoras, **1**, 112.
- Crowbar, modified form of lever, **6**, 57.
- Ctesibius, his studies of the problems of matter, **1**, 243; invention of mechanism to show that heat can do mechanical work, **1**, 247; fire-engine of, described, **6**, 63; studies phenomena of suction, **6**, 94.
- Cugnot, manufactured a steam-driven wagon, **7**, 158.
- Cunard, Samuel, the founder of the Cunard Line, **7**, 74.
- Cupping-glass, **6**, 64.
- Curie, Madame Skaldowska, discovery of radium, **5**, 100; the theories of radio-activity of, **5**, 106.
- Curie, Professor Pierre, discovery of radium, **5**, 100; the theories of radio-activity of, **5**, 106.
- Curtiss, Glenn H., his successful flight from Albany to New York, **7**, 296.
- Cuvier, George, his investigations concerning extinct species, **3**, 78; his inquiries respecting the fabulous animals of the ancients, **3**, 81; agrees with Smith's views, **3**, 83; on catastrophism, **3**, 85; rejects the fossils discovered by Dr. Schmerling, **3**, 103; his classification of the animal kingdom, **4**, 102; his law of co-ordination, **4**, 107; his opposition to the transmutation doctrines, **4**, 153, 158.
- Cyclones, **3**, 199-205; a system of whirls, **3**, 202; primary cause of, **3**, 203; anti-, **3**, 204.
- Cyrus the Great, his use of the wireless telegraph, **8**, 3; an interesting cylinder recording his victories now preserved in the British Museum, **8**, 105.
- DART, Leo, the inventions of, **7**, 184.
- Da Gama, Vasco, navigated to India by way of the Cape of Good Hope, **7**, 46.
- Daguerre, Louis J. M., brought photography to perfection, **4**, 70; **8**, 202; discovered a practical method of developing photographic plates, **8**,

KEY AND INDEX

- 220; his attention directed to the subject of photography, **8**, 223; inventor of the daguerreotype process, **8**, 224.
- Daguerreotype perfected by Louis Daguerre in 1839, **4**, 70; **8**, 224.
- Daimler, German inventor, who applied a high-speed oil engine to the automobile in 1884, **6**, 140; used the gasoline motor for the practical propulsion of a tricycle, **7**, 157.
- D'Alembert, Jean le Rond, determined the ratio of the attractive forces of the sun and moon, and the mutation of the axis of the earth, **3**, 15.
- Dalton, Chemistry Since the Time of, Chapter III, **4**, 38.
- Dalton, John, and the atomic theory, **4**, 38-46; first conception of the chemical atom, **4**, 39; his theory disputed, **4**, 41; his theory adopted, **4**, 44; predicted the liquefaction of gases, **5**, 40.
- Daniell, John Frederick, produced the cell which bears his name, **3**, 236.
- Dark Age, Science in the, Chapter I, **2**, 3.
- Darwin, Charles Robert, his *Origin of Species*, **3**, 95; his work a revelation to the geological world, **3**, 96; his work on doctrine of evolution, **4**, 167; his most available field, **4**, 168; years spent in gathering facts, **4**, 171; joint paper of, and Wallace, presented to the Linnæan Society of London, **4**, 173; makes converts of Hooker, Lyell, and Huxley, **4**, 174; entombed in Westminster Abbey, **4**, 178; statue of, in Museum of Natural History, **5**, 9; computations as to the earth's ultimate fate, **5**, 212.
- Darwin, Dr. Erasmus, his theory concerning the aurora borealis, **3**, 173; concerning the vapor of water, **3**, 177; and vegetable respiration, **4**, 94-99; his *Botanic Garden*, **4**, 147; his *Zoönomia* and *Temple of Nature*, **4**, 148; his expression of the idea of organic evolution, *ibid.*; at his death his idea of transmutation of species still an unsubstantiated dream, **4**, 149.
- Darwinian theory, its development, **4**, 166; greatest scientific conception of the nineteenth century, **5**, 241.
- Davenport, Thomas, has the distinction of building the pioneer electric road, **7**, 178.
- Davenport, English potters who early produced wares of superior quality, **9**, 232.
- Da Vinci, Leonardo, his theories concerning the creation similar to those expressed by Xenophanes two thousand years before, **1**, 129; sketches of flying-machines by, **7**, 227.
- Davy, Sir Humphry, produced the first electric lamp, **3**, 234; his own account of his experiments, **6**, 220; showed that labor may be transformed into heat, **3**, 255; his experiment of melting ice by friction, **3**, 277; heat a manifestation of motion among particles of matter, **3**, 294; and electro-chemistry, **4**, 46-53; brilliant researches with his voltaic battery, **4**, 47; his famous Bakerian lecture **4**, 48; his theory of binary composition of chemical compounds, **4**, 53; experiments in the mysteries of respiration, **4**, 93; experiments with nitrous oxide, **4**, 209-212; professor of chemistry in Royal Institute, **5**, 34; his science of electro-chemistry, **5**, 36; experiments with low temperatures, **5**, 40; his suggestion results in production of liquid chlorine, **5**, 41; experiments upon gases, **5**, 42; challenged the theory of

GENERAL INDEX

- imponderable fluids as applied to light and heat, **6**, 154; safety lamp of, **6**, 250; his experiments with the camera obscura, **8**, 221.
- Dawes, Rev. W. R., one of the discoverers of the inner or crape ring of Saturn, **3**, 44.
- Day of Bel, the, a series of tablets written in the time of Sargon I., 3800 B.C., **1**, 67.
- Days, lucky and unlucky, according to Egyptian magicians, **1**, 44, 45, 46.
- De Bary, Heinrich, studies of protoplasm, **4**, 125.
- De Caus, Solomon, put into effect the idea of utilizing steam for the practical purpose of raising water, **6**, 83.
- DeForest, Lee, inventor of wireless telegraph system used during the Russo-Japanese war, **8**, 65; instruments used by, in experimenting with wireless telephony, **8**, 90.
- De Gary, Blasco, constructed the model of a paddle-wheel steamboat, **7**, 66.
- Degen, invented a flying-machine with two parachutes, **7**, 245.
- De Jussieu, Antoine and Bernard, founders of the "natural system in botany," **2**, 303.
- De Lacaille, Nicolas Louis, his remeasurement of the French arc of the meridian, in 1739, **3**, 13; the question of the shape of the earth, **3**, 14.
- De Lamarck, Jean Baptiste, the work of, **4**, 151; his idea of transmutation of species, **4**, 152; coined the word "biology," **4**, 160.
- Delambre, Jean Baptiste Joseph, determined the orbit of the planet Uranus, **3**, 16; investigated Alexandre's telegraph, **8**, 10.
- DeLaval, Dr. Gustav, turbine engine of, **6**, 131.
- Delitzsch, Professor, his Assyrian grammar, **1**, 96.
- De Maillet, and transmutation of species, **4**, 149.
- Demeny, George, devised the photoscope for reproducing the motion of a man's lips, **8**, 250.
- Democedes, the first physician of whom we have any trustworthy history, **1**, 172.
- Democritus, a dreamer and a thinker, **1**, 162; his theory of atoms curiously foreshadowed nineteenth-century knowledge, **1**, 163; atoms differ from each other only in size and shape, **1**, 164; the quibble over the word quality, **1**, 166; a forecast of the chemistry of the future, **1**, 167, 169; a believer in omens, **1**, 170.
- De Morgan, a worker in the field of Egyptian exploration, **1**, 28.
- De Rouge, Vicompte E., a follower of Dr. Young in the study of Egyptian hieroglyphics, **1**, 27; theories of his followers concerning the symbols of the Phœnician alphabet, **1**, 87.
- Derrick, see Crane.
- Desaguliers, Dr. Joseph, electrifies running water, **2**, 274; originates story of invention of beam connection for operating engine valves, by Humphrey Potter, cock-boy, **6**, 91.
- Descartes, René, statement of the first law of motion, **2**, 99; formulates law of refraction, **2**, 119; estimates of his work, **2**, 193; his physiological views, **2**, 194; theory of vortices, **2**, 195.
- Desmoulins, Louis Antoine, his studies of the brain, **4**, 249.
- Deutschland and Kaiser Wilhelm II.* German ships that for several years held the ocean record for speed, **7**, 82.
- Devaine, discovery that anthrax is caused by bacteria, **4**, 227.
- Development of the Alphabet, The, Chapter IV, **1**, p. 86.

KEY AND INDEX

- Development of Modern Geology, The Origin and, Chapter IV, **3**, 116.
- Development of Electricity and Magnetism, The Modern, Chapter VII, **3**, 229.
- Development of Electric Railways, The, Chapter VI, **7**, 175.
- Déville, Ste.-Claire, dissolution and reformation of molecules fully appreciated by, **4**, 61.
- De Vinne, Theodore L., his description of a perfected magazine press, **8**, 135.
- Dewar, Professor James, experiments with low temperatures, **5**, 39; liquefied "hydrogen," **5**, 43; his vacuum vessel for holding liquefied gases, **5**, 53, 54, 68; his experiments show that carbon will liquefy under pressure of about fifteen tons to the square inch, **9**, 327.
- Diamond Drill, **6**, 247.
- Dias, Bartholomeo, discovered the Cape of Good Hope, **7**, 46.
- Diesbach, accidentally discovered a blue pigment, **8**, 299.
- Digestion, chemical theory of, **4**, 88-91; function of the glands that act in the process of, **4**, 129, 130.
- Diodorus, the Sicilian, **1**, 56; left us a striking summary of Babylonian science, **1**, 77; describes pyramid-building in Egypt, **6**, 37.
- Diogenes Laertius, his story of the athletic prowess of Pythagoras, **1**, 112.
- Diphtheria, discovery of anti-toxine for, **4**, 242.
- Disputed question of "spontaneous" variations, **4**, 178; Haeckel and Spencer and the, *ibid.*
- "Dissociation," the dissolution and reformation of molecules in a substance, **4**, 61.
- Doctrine of irritability, Haller's greatest contribution to medical science, **4**, 74.
- Dog, first animal to be domesticated, still used as beast of burden, **6**, 59.
- Dohrn, Dr. Anton, founder of the Marine Biological Laboratory at Naples, **5**, 121; theory of the annelid type of invertebrate ancestor of the vertebrates, **5**, 137.
- Domestic economy, methods at beginning nineteenth century compared with those at end, **6**, 22-24.
- Door, a lever of the second class, **6**, 30.
- Doors of ancient dwellings, **9**, 155.
- Dove, Heinrich W., his studies in climatology, **3**, 199, 200.
- Dow, type-setting machine of, **8**, 151.
- Drais, Baron von, the earliest bicycle introduced by, **7**, 154.
- Draper, Dr. Henry, made the first successful photograph of a nebula, **3**, 67.
- Draper, Dr. John W., application of photography to spectroscopy, **4**, 70; in connection with Morse succeeded in making the first photographic portrait ever taken, **8**, 226.
- Dreadnought, Atlantic record for sailing vessels made by, **7**, 62.
- Driesch, Dr., studies of cell activities and of heredity made at the Marine Biological Laboratory at Naples, **5**, 131.
- Drill, a modified form of the lever, **6**, 57; used in mining, **6**, 254.
- Dubois, Dr. Eugene, the discoverer of the ape-man fossil on the island of Java, **3**, 113; discovers the skull and thigh-bone of the ape-man of Java, **5**, 173; the "missing link," **5**, 174; an important addition to our knowledge of man's line of descent made by discoveries of, **5**, 176.
- Ductless glands, their functions discovered by Claude Bernard, **4**, 137.

GENERAL INDEX

- Dufay, Cisternay, electrical experiments, 2, 267; discovers "vitreous" and "resinous" electricity, 2, 270; established important facts regarding conduction and insulation, 6, 219.
- Dujardin, contents of cells named "sarcode" by, 4, 124.
- Dumas, Jean Baptiste, his school of physiological chemistry, 4, 128.
- Dundas, Lord, engaged Symington to build a steam boat to be used for towing, 7, 67.
- Dunlap, J. B., introduced the pneumatic tire, 7, 155.
- Dürer, Albrecht, best known wood engravings made by, 8, 188.
- Durouf, his use of the balloon during the Franco-Prussian War, 7, 258.
- Dutartre, the stop cylinder invented by, 8, 125.
- Dwelling House, evolution of, 9, 133; the cave-dwellers, 9, 134; material used in building determined by the natural products at hand, 9, 138; methods of construction, and architecture, 9, 140; the use of chimneys, 9, 151; the first glass windows, 9, 153; different types of roofs, 9, 153; ceilings and floors, 9, 154; staircases, 9, 155; doors of ancient dwellings, 9, 155.
- Dyes, their origin, composition, and uses, 8, 314.
- Dynamo, The, 6, 171; the mechanism of, 6, 173; complex structure of, 6, 174; origin of, 6, 176; dynamo-electric machine, constructed by Michael Faraday, 6, 177; Wilde's separately excited, 6, 178; introduction of the ring arrangement, 6, 179; amount of loss of energy in, 6, 180; in the electric power plant at Niagara Falls, 6, 187.
- EARL of Stanhope, produced a printing-press having a frame made of one piece of cast iron, 8, 122.
- Early Greek Philosophers in Italy, The, Chapter VI, 1, 112.
- Earth, the, ultimate fate of, 5, 212; future life of, 5, 213; as a conductor of electricity, 8, 48.
- Earth's crust, the, computation as to the age of, 5, 210; estimated thickness of, 5, 212.
- Eaton, William, inventor of the self-acting mule, 9, 35.
- École Polytechnique, Paris, Discovery of "radium" at, 5, 100.
- Economic condition of Europe, its influence on science in the dark age, 2, 6.
- Edison, Thomas A., his invention of the incandescent lamp, 6, 228; perfected a series of electric-railway motors and locomotives, 7, 182; the storage-battery car invented by, 7, 189; patents a system of wireless telegraphy, 8, 50; improves upon the type of telephone receiver, 8, 83; invents a microphone transmitter, 8, 83; inventor of the phonograph, 8, 93; his invention of the kinetoscope, 8, 251.
- Egg-cell, contents of, 5, 227.
- Egypt, the first dynasty, 1, 31; the building of the pyramids, 1, 32; three seasons of, 1, 36.
- Egyptian antiquities captured by the English, 5, 5.
- Egyptian Science, Chapter II, 1, 25.
- Egyptian science, the summer solstice corresponded with the rising of the Nile, 1, 34; the year divided into twelve months of thirty days each, 1, 35; the three seasons, 1, 36; the fixing of New Year's day, 1, 37; the difficulties concerning the unreckoned quarter of a day, 1, 38; efforts to reform the calendar, 1, 40; arbitrary signs of the zodiac,

KEY AND INDEX

- 1, 41**; conceptions concerning the earth, sky, etc., **1, 42**; the recognition of the pulse, **1, 51**; practical mathematics, **1, 52**; science as science was unknown, **1, 55**.
- Egyptian seasons, three in number, **1, 36**.
- Egyptian temples, oriented with reference to the point at which the sun rises on the day of the summer solstice, **1, 34**.
- Eighteenth-Century Medicine, Chapter VII, **4, 182**.
- Eleatic School, founded by Xenophanes, **1, 114**.
- Electricity, Progress in, from Gilbert and Von Guericke to Franklin, Chapter XIV, **2, 259**.
- Electricity and Magnetism, The Modern Development of, Chapter VII, **3, 229**.
- Electricity, Oersted's experiments with suspended magnetic needle, **3, 236**; its relation to magnetism, **3, 238**; the discovery of the principles of electro-dynamics, **3, 239**; the first electro-magnet, *ibid.*; experiments of Michael Faraday, **3, 243**; the first storage battery, **3, 246**; Seebeck's battery, **3, 247**; the "Hertzian Waves," now used in wireless telegraphy, **3, 247**; Professor Thompson and the nature of, **5, 92**; relation of gases to the conduction of, *ibid.*; atomic character of, **5, 96**; regarded as a form of matter, **5, 97**; Age of, **6, 15**; general chapter on, **6, 148**; theories as to what it is, **6, 149**; multiform uses of, in every-day life, **6, 149**; Benjamin Franklin's one-fluid theory of, **6, 150**; two-fluid theory of, **6, 151**; name derived from Latin word *electricum*, **6, 152**; derivation of the idea that it is a "fluid," **6, 153**; modern views of, **6, 153**; studies of Rumford,
- Young, Fresnel, and Davy, leading up to modern theories, **6, 154**; most recent views as to the nature, **6, 155**; currents of, simply aggregations of free electrons, **6, 156**; how it is developed, **6, 159**; statical and dynamical, **6, 160**; generation of, by walking on a wool carpet in cold weather, **6, 160**; amount generated by lightning, **6, 161**; the static machine, **6, 161**; the work of the dynamical current, **6, 162**; voltaic cell for generating, **6, 163**; theories of electrical action, **6, 165**; practical uses of, **6, 168**; current of, used for producing heat, **6, 169**; dynamos for generating, **6, 174**; mechanism of its production by the dynamo, **6, 181**; amount generated at Niagara Falls, **6, 189**; transmission of, from Niagara Falls, **6, 194**; loss in transmission of, as estimated by Siemens, **6, 195**; transmission of, at Niagara by recent methods, **6, 197**; "step up" and "step-down" transformers, **6, 198**; high and low voltage, **6, 199**; Ruhmkorff coil, the construction of, **6, 199**; traction engines used in mining, **6, 257**; engine invented by W. M. Schlessinger, **6, 257**; in coal-mining, **6, 266**; electric lighting of mines, **6, 269**; obtaining nitrogen from the air by the use of, **6, 307**; and high temperatures, **6, 313**; the discovery of, **8, 4**.
- Electric light, Sir Humphry Davy's experiments with, **3, 234**; first ever invented, by Sir Humphry Davy, **6, 220**; first practical application of, in France, 1849, **6, 222**; the improved arc light, **6, 226**; Chas. F. Brush's invention of arc light, **6, 226**; some recent types of arc lights, **6, 227**;

GENERAL INDEX

- carbons for, invented by Carré, 6, 227; incandescent, 6, 228; Thos. A. Edison's invention of the incandescent lamp, 6, 228; defects of platinum wire as filament for incandescent lamp, 6, 230; carbon as a filament for incandescent lamp 6, 233; method of preparing carbon filament for incandescent lamp, 6, 233; the tungsten lamp, 6, 234; advantages and defects of tungsten lamp, 6, 235; Mercury-vapor light of Peter Cooper Hewitt, 6, 236.
- Electric Railways, the development of, 7, 175; the first practical cable system invented by Andrew S. Hallidie, 7, 177; the small circular railway built by Thomas Davenport, 7, 178; the electro-magnetic locomotive of Moses G. Farmer, 7, 179; the small working-motor exhibited by Thomas Hall, 7, 179; the efforts of Professor Page to produce a storage-battery car, 7, 180; the experiments of Siemens and Halske with electric motors, 7, 181; the Edison electric locomotive, 7, 182; third rails and trolleys, 7, 184; the inventions of Daft and Van Depoele, 7, 185; the work of Frank J. Sprague in developing electric railways, 7, 186; the storage battery line built by E. Julien, 7, 188; improvements made by Anthony Rackenzaun, 7, 189; the Edison storage-battery car, 7, 189; monorail systems, 7, 191; the monorail system invented by Howard Hansel Tunis, 7, 193.
- Electro-chemistry, the new science of, 6, 298; its use in obtaining nitrogen from the air, 6, 307.
- Electro-magnetism, 8, 14.
- Electron, composition of, and newest theories about, 6, 148; and radio-active substances, 6, 156; Sir J. J. Thomson's conception of, 6, 158; theory of origin of, 6, 165; in its relation to the atom, 6, 156, 166.
- Electroplating, action of electricity in, 6, 170.
- Elevator, hydraulic, principle of, described, 6, 76-77; the invention of, by Elisha G. Otis, 9, 160.
- Elixir of life, 2, 124, 131, 136.
- Ellis, Alexander J., gives information to Graham Bell as to experiments on sounds performed by Helmholtz, 8, 75.
- Embalming the dead, a purely religious observance in Egypt, 1, 50; to prevent the spirit's return to torment one, 1, 54.
- Embryological development, theory of, 5, 156.
- Embryology, studies in, by Von Baer, Müller, and Carpenter, 4, 122.
- Empedocles, one of the great Italic leaders of thought, 1, 114; a practising physician, 1, 133; his work as a sanitary engineer, 1, 134; his idea of the impersonality of God, 1, 135; his knowledge of embalming, 1, 136; his conception of evolution, 1, 137; he had a secure place among the anticipators of the modern evolutionist, 1, 138; his studies of the force of air pressure, 1, 247.
- Energy, The Conservation of, Chapter VIII, 3, 253.
- Energy, chief sources of, at man's disposal, 6, 41-42; man learns to use energy of animals, 6, 59 *seq.*; uses of, contained in air and water, 6, 62.
- Engines, see Atmospheric e., Electric e., Gas e., Hot-Air e., Piston e., Steam e., Water e.

KEY AND INDEX

- Epagomenal days**, the legend of Osiris explaining, **1**, 36.
- Epicycles**, the doctrine of wheels, **1**, 237.
- Erasistratus**, one of the first to discover that the nerve-trunks have their origin in the brain and spinal cord, **1**, 194; his disagreement with Herophilus as to the functions of the organs, **1**, 195.
- Eratosthenes**, called the "surveyor of the world," **1**, 226; his important modification of the gnomon, **1**, 227; his method of determining the size of the earth, **1**, 230; his conclusions have ever been regarded with admiration, **1**, 231; additional reference to his measurement of the world, **7**, 5.
- Ericsson**, John, built caloric engines on such a scale as to be adapted to the propulsion of ships **6**, 134.
- Erman**, Professor, an Egyptologist, **1**, 28.
- Ernst Haeckel** and the New Zoology, Chapter VI, **5**, 144.
- Etching**, **8**, 195; Rembrandt and Van Dyck famous for their etchings, **8**, 196; Whistler and Seymour Haden great exponents of this kind of engraving, **8**, 196.
- Ether and Ponderable Matter**, The, Chapter IX, **3**, 283.
- Ether**, James Clerk-Maxwell's conception of, **3**, 283; its discovery one of the most important feats of the nineteenth century, **3**, 284; discovered by Thomas Young, **3**, 285; the speculations concerning it, **3**, 286, 290.
- Etienne**, Charles, discovers canal in spinal cord, **2**, 163.
- Euclid**, the father of systematic geometry, **1**, 193.
- Eudoxus**, made special studies of the heavenly spheres, **1**, 216; remarked the obliquity of the ecliptic, **1**, 228.
- Euler**, Leonard, professor of physics and mathematics at St. Petersburg, **3**, 17; his demonstration concerning the aphelia of Saturn and Jupiter, **3**, 18.
- Eustachius**, sixteenth-century anatomist, **2**, 165; tube, *ibid.*
- Evans**, Oliver, experiments with high-pressure steam, designs road vehicle, **6**, 113; his machine the "Oruktor Amphibious" combined the principle of steamboat and locomotive, **7**, 121.
- Evolution**, Professor Marsh on, **3**, 114.
- Evolution**, Theories of Organic, Chapter VI, **4**, 140.
- Evolution of the Dwelling House**, Chapter VI, **9**, 133.
- Existence**, struggle for, explained and exemplified, **6**, 3-6.
- Experiment**, the first passenger coach, **7**, 120.
- Experimental Psychology**, The New Science of, Chapter IX, **4**, 245-286.
- Eyde**, S., his co-operation with Prof. Birkeland in obtaining nitrogen from the air, **6**, 306.
- FALCONER**, Dr., his description of the fossil remains in the museum of M. de Perthes, **3**, 100.
- Fallopian**, sixteenth-century anatomist, **2**, 166.
- Faraday**, Sir Michael, begins the study of electro-magnetic induction, **3**, 240; his paper before the Royal Society, **3**, 241; his rotating disk, **3**, 245; just missed the discovery of the conservation of energy, **3**, 253; claimed the existence of an invisible plenum everywhere in space, **3**, 287; produces liquid chlorine, **5**, 39; experiments with gases, **6**, 40; hoped to establish a relation between gravitation and

GENERAL INDEX

- electricity or magnetism, **5**, 215; the idea of action of distance repugnant to his mind, **6**, 155; his invention of the dynamo-electric machine, **6**, 177.
- Faraday tubes, nature of, **6**, 159.
- Farman, Henry, his successful flight, **7**, 293.
- Farmer, Moses G., constructed an electro-magnetic locomotive, **7**, 179.
- Favus, cause of, **4**, 208.
- Fechner, Gustav, his *Psychophysik*, **4**, 263; verifies Weber's fundamental law of psychophysics, **4**, 266.
- Fegaunt, Lieutenant, and Captain Marconet, made a cross-country flight in a Farman bi-plane, **7**, 298.
- Feil succeeded in making crystals of a size from which gems could be cut, **9**, 331.
- Ferrel, Professor William, formulated a general mathematical law concerning wind currents, **3**, 200.
- Ferrier, Dr. David, and brain localization, **4**, 273.
- Field, Cyrus W., his connection with the laying of the Atlantic cable, **8**, 30; aboard the *Great Eastern* on its first cable-laying expedition, **8**, 42.
- Field, Stephen D., his experiments with the electric motors, **7**, 181.
- Fifteenth-century medicine, **2**, 39.
- Fielding and Platt, their working model of a rotary engine in the South Kensington Museum, **6**, 122.
- Finding the time without a chronometer, **7**, 28.
- Fire Damp, in mines, **6**, 249.
- Fire-engine, device of Ctesibius described, **6**, 63.
- Fitch, John, his efforts to perfect a steamboat, **7**, 63.
- Fizeau, M., invented the process of toning or gilding photographs with a solution of gold, **8**, 228.
- Fleury, Cardinal, as French Minister in 1728 concerned himself with fashions in hoop skirts, **9**, 74.
- Flinders, Matthew, his discovery that the influence of the ship over its compass varies with the direction of the ship's prow, **7**, 11.
- Floods, those of the Nile, the Tigris, and Euphrates a most tangible index of the seasons, **1**, 66.
- Flourens, Marie Jean Pierre, experiments in nerve physiology, **4**, 270; discovers the "vital knot," *ibid.*
- Floors, ancient, **9**, 154.
- Flying Cloud*, speed made by, **7**, 62.
- Forbes, the discoverer of the polarization of heat, **3**, 278.
- "Force" of cohesion, **5**, 49.
- Fossil beds of America, the, finest known, **3**, 106.
- Fossil man, the collection of M. Boucher de Perthes, **3**, 100.
- Fossil horse described by Professor Marsh, **3**, 108.
- Foster, Sir Michael, permanent secretary Royal Society of London, **5**, 17.
- Fouqué, French chemist, his analysis of the blue pigment used by the Egyptians, **8**, 302.
- Fourneyron, invents turbine wheel, **6**, 72.
- Franco, Peter, itinerant surgeon, **2**, 182.
- Frank, associated with Caro in perfecting process of nitrogen fixation, **6**, 309.
- Franklin, Benjamin, electrical experiments, **2**, 286; his theory of electricity, **2**, 288; **6**, 150; his battery, **2**, 289; invents the lightning-rod, **2**, 290; proves that lightning is electricity, **2**, 293; his theory concerning the aurora borealis, **3**, 173; concerning the vapor of water, **3**, 177; pointed out

KEY AND INDEX

- that water carries sound farther and faster than air, and with greater constancy, 7, 85; invented the "Franklin stove," 9, 167.
- Fraunhofer, Joseph, the perfecter of the refracting telescope and the "heliometer," 3, 60.
- Fremy, succeeded in making crystals of a size from which gems could be cut, 9, 331.
- Fresnel, Augustin Jean, champions Dr. Young's wave theory of light, 3, 226; elected a member of the French Academy, *ibid.*; challenged the doctrine of imponderable fluids as applied to light and heat, 6, 153.
- Friction, 6, 39-41; friction reducers, 6, 54, *seq.*
- From Cart to Automobile, Chapter V, 7, 152.
- From Paracelsus to Harvey, Chapter VII, 2, 156.
- Fuhlrott, Dr., his discoveries in a cave at Neanderthal, 3, 102.
- Fulton, Robert, inventor of the *Clermont*, the first practical steamboat, 7, 70; built the first war steamer and ocean steamer ever attempted, 7, 73; his experiments with submarine boats, 7, 98; the *Nautilus*, his first submarine, 7, 99.
- Furniture and Furnishings, Chapter IX, 9, 213-224.
- Furniture and Furnishings, early types of, 9, 213; the beginning of the time of modern furniture, 9, 216; the passing of hand carving, 9, 217; other ingenious tools used in furniture-making, 9, 223.
- GALE répercutée, 4, 204, 205.
- Galen, the last great scientist of the Alexandrian school, 1, 272; a tireless worker, 1, 277; his erroneous conceptions regarding the heart, 1, 278; his treatment of the *ulnar* nerve, 1, 279; his treatment of Emperor Marcus Aurelius, 1, 280; his system of treatment, 1, 281; his erroneous theories about respiration and the pulse beat, 1, 282; his observations of the skin and heart, 1, 283.
- Galileo, Galilei, life and work, 2, 76; construction of telescope, 2, 78, 253; telescopic observations, 2, 78, 79, 80; discovery of sun-spots, 2, 80; trial for heresy, 2, 81; publication of his work, 2, 83; extract from his work, 2, 84; experiment at Pisa, 2, 94; theory in regard to projectiles, 2, 95; mechanical discoveries, 2, 98; experiments with inclined planes, 2, 100; with pendulum, 2, 100; experiments with fluids, 2, 105; account of his experiments with floating bodies, in his own words, 2, 106; invents the thermometer, 2, 119.
- Galileo and the New Physics, Chapter V, 2, 93.
- Galileo, The Successors of, in Physical Science, Chapter X, 2, 204.
- Gall, Dr. Franz Joseph, studies in phrenology, 4, 247.
- Gallium discovered, 4, 68.
- Galvani, Luigi, the discoverer of the new agent galvanism, 3, 229; his experiments with frogs' legs, 3, 230; his experiments paved the way for the electric light, 6, 219.
- Ganglion cells, studies of, 4, 279.
- Garnerin, the folding umbrella-like parachute invented by, 7, 243.
- Gas, term coined by Van Helmont, 2, 186.
- Gas, Acetylene, 6, 212; use of calcium carbide in producing, 6, 213; discovery of its use for illuminating by Thos. F. Wilson, 6, 213; Niagara Falls the centre of carbide manu-

GENERAL INDEX

- facturing industry, 6, 214; cost of production of, 6, 215; defects of, 6, 215; lamps for burning, 6, 216; at the Pan-American Exhibition at Buffalo, 6, 216; proper method of generating, 6, 217.
- Gas and Oil Engines, Chapter on, 6, 132.
- Gas engine, principle of, 6, 132; of Sir G. Cayley, 6, 132; early attempts to invent, 6, 134; first practical one invented by J. J. E. Lenoir, 6, 135; principle on which modern gas engines work, 6, 135; method of operation in perfected type, 6, 138; introduction of a volatile oil for supplying the gas, 6, 139; G. Daimler's development in 1884, 6, 140; modern form of motor devised by Messrs. Panhard and Levassor, 6, 140; difficulties to be overcome in perfecting it precisely opposite to those of the steam engine, 6, 140; status of, as compared with steam engines, 6, 141; reason for exploding the mixed gases in the oil engine, 6, 144.
- Gas, illuminating, flat burner invented by Neilson in 1820, 6, 208; invention of the incandescent mantle, 6, 208; Clamond mantle used in 1882, 6, 209; used for producing "lime light," 6, 209; Dr. Auer von Welsbach's perfected incandescent burner, 6, 210; acetylene used for, 6, 212; part played by electric furnace in producing acetylene gas, 6, 213.
- Gases, liquefied, 5, 40-42; methods used, 5, 45, 46; Dewar's vacuum vessel for holding, 5, 53; new, discovered by Dr. Ramsey, 5, 84; questions raised by discovery, 5, 89-91; their relation to the conduction of electricity, 5, 93.
- Gas mantle, 6, 211.
- Gastric juice, Réaumur's experiments with, 4, 89; Spallanzani's and Hunter's theories of, *ibid.*; action of, after death, 4, 90; hydrochloric acid discovered in, 4, 129; pepsin, active principle in, *ibid.*
- Gaudin, produced true rubies of microscopic size, 9, 331.
- Gauss, one of the first inventors of a practical working telegraph, 8, 17.
- Gay-Lussac, Joseph Louis, experiments with gases, 4, 42.
- Gears, levers of the second class, 6, 35-36.
- Geber, Arabian chemist, 2, 20.
- Gems, Natural and Artificial, Chapter XII, 9, 295; "lucky" and "unlucky" stones, 9, 295; confused nomenclature, 9, 297; practical tests, 9, 300; the cutting of precious stones, 9, 305; diamonds in the rough, 9, 312; the ruby and its allies, 9, 319; artificial gems, 9, 327.
- Genealogical tree, Haeckel's, regarding the ancestry of man, 5, 172; the "missing link," 5, 173.
- Gennes, M. de, French Naval officer who suggested plans for a power-loom, 9, 43.
- Geocentric theory, 1, 217.
- Geology, The Origin and Development of Modern, Chapter IV, 3, 116.
- Geometry, according to Herodotus, was invented in Egypt, 1, 107.
- Gérard, the flying-machine of, 7, 241.
- Gerlach, the histological scheme of, 4, 281.
- Germanium discovered, 4, 68.
- Giant, the voyages of the, 7, 252.
- Giffard, "the Fulton of aerial navigation," 7, 251.
- Gifford, George, a New York lawyer, his argument for the validity of Howe's sewing-machine patent, 9, 93.

KEY AND INDEX

- Gilbert, William, study of magnetism, 2, 111; 6, 175; 7, 10; the earth a magnet, 2, 113; "dipping" of the needle, 2, 114; other discoveries, 2, 116.
- Gill, Dr. David, at the Cape observatory made the first photograph of a comet, 3, 67.
- Gillebrand, Professor, English professor of geometry who independently discovered that the declination of the compass varies from time to time, 7, 10.
- Gintl, Doctor, invents an instrument for sending telegraphic messages in opposite directions at the same time, 8, 25.
- Glaciers, the phenomena of, 3, 147; the moraines, 3, 148; the perched bowlders, *ibid.*; the polished and striated rocks, the lapiaz, 3, 149; the ancient moraines, 3, 150; perched bowlders in the Alpine valley, 3, 152; Agassiz's *Études sur les Glaciers*, 3, 154; treated with contempt by most scientists, *ibid.*; a mile deep over New England, 3, 163; the results following the rending of the ice sheet, 3, 164.
- Glands, discovery of, in the mucous membrane, 4, 129.
- Glass and Glass-making, Chapter XI, 9, 277; its origin unknown, 9, 277; important developments that glass has made possible, 9, 278; probable discoveries of glass, 9, 279; a doubtful Roman tradition, 9, 281; the composition of glass, 9, 284; the process of manufacturing window glass, 9, 287; plate-glass making, 9, 291; cut glass, 9, 293; "wire-glass," 9, 294.
- Glass negatives, invented by Niepce St. Victor, 8, 229.
- Glass windows, the first, 9, 153.
- Globe, the, constructed by Stephenson for use on the Stockton & Darlington Railway, 7, 134.
- Gloves, Manufacture of. See Clothing the Extremities, 9, 103.
- Glycerine discovered by Karl Wilhelm Scheele, 4, 27.
- Goddard, discovered that bromine vapor rendered photographic plates more sensitive, 8, 228.
- Godfrey, Thomas, discovered a means of measuring the altitude of astronomical bodies, 7, 20.
- Goethe, Johann Wolfgang, studies of the metamorphosis of plants, 4, 140-145; extends the doctrine to the animal kingdom, 4, 146.
- Golgi, Dr. Camille, process of staining nerve cells, 4, 282.
- Goodson, J. H., the graphotype invented by, 8, 149.
- Goodyear, inventor of the "turn shoe" machine, automatic heeling-machine, etc., 9, 113.
- Gordon, Andrew, his electric motor and bell, 2, 279.
- Graebe, effected the synthesis of alizarine, 8, 313.
- Graham, Mr., discovered daily variations of the compass, 7, 10.
- Gralath, Daniel, groups Leyden jars in a "battery," 2, 283.
- Gramme, re-invented the ring dynamo, 6, 179.
- Granville, W. P., system of wireless telegraphy installed by, 8, 51.
- Gravitation, Newton and the Law of, Chapter XII, 2, 236.
- Gravitation, law of, discovered by Isaac Newton, 2, 236; Newtonian laws apply to every particle of matter in the universe, 3, 58; power of, 5, 214; hope of establishing a relation between, and electricity or magnetism, 5, 215; so-called law of, 5, 231.

GENERAL INDEX

- Gray, Asa, became an ardent propagandist, **4**, 175.
- Gray, Prof. Elisha, his experiments with submarine signaling, **7**, 85; invents a system for sending multiple messages, **8**, 26; inventor of a practical telephone, **8**, 73; controversy with Bell, **8**, 81.
- Gray, Stephen, experiments with electric conduction and insulation, **2**, 262; **6**, 219; modern telegraph made possible by his discovery that electricity could be conducted practically unlimited distances by means of wires or threads, **8**, 4.
- Gray, Thomas, suggest the construction of a railroad for passenger and freight traffic, **7**, 127.
- Great Eastern*, description of the, **7**, 77; the part it played in the laying of the Atlantic cable, **8**, 42.
- Great Republic*, description of the, **7**, 61.
- Great Western*, made a record voyage, for the first time using steam alone as a motive power, **7**, 73.
- Greek Philosophers in Italy, The Early, Chapter VI, **1**, 112.
- Greek Science, The Beginnings of, Chapter V, **1**, 103.
- Greek Science in the Early Attic Period, Chapter VII, **1**, 139.
- Greek Science of the Alexandrian or Hellenistic Period, Chapter IX, **1**, 189.
- Greenough, John J., inventor of a sewing-machine using a double-pointed needle, **9**, 91.
- Guericke, Otto von. See von Guericke.
- Guérin, Alphonse, endeavors to protect wounds from germs, **4**, 230.
- Guimet, French chemist who synthesized the pigment ultra-marine in 1828, **8**, 297.
- Gulf Stream, the, theories of Humboldt and Maury concerning it, **3**, 196; it carries an enormous quantity of heat, **3**, 197; its effect on the climate of the seaboard of the United States and Europe, **3**, 198.
- Gun-shot wounds, effect on surgery in the sixteenth century, **2**, 41.
- Gurney, opposition to the automobile invented by, **7**, 160.
- Gutenberg, Johannes, the father of printing, **8**, 120; his press the simplest and first, **8**, 120.
- Guy of Chauliac, the effect of his methods upon mediæval surgery, **2**, 38.
- Gyrocar, The, Chapter VII, **7**, 195; gyroscopic action explained, **7**, 197; Mr. Brennan's model car, **7**, 200; How the Brennan gyroscopes work, **7**, 203; the evolution of an idea, **7**, 213.
- Gyroscope and Ocean Travel, The, Chapter VIII, **7**, 217; the idea of the gyroscope on ships put into fairly successful operation by Professor Piazzi Smyth, **7**, 217; Bessemer's costly experiment, **7**, 217; Dr. Schlick's successful experiment, **7**, 219; did gyroscopic action wreck the *Viper*? **7**, 222; theoretical dangers of the gyroscope, **7**, 223.
- Gyroscopic action explained, **7**, 197.
- HADEN, Seymour, one of the great exponents of the type of engraving known as etching, **8**, 196.
- Hadley, John, devised an instrument called the quadrant for measuring the altitude of astronomical bodies, **7**, 20.
- Haeckel, Ernst Heinrich, and the Darwinian theory, **4**, 175; and the disputed ques-

KEY AND INDEX

- tion of "spontaneous variations," 4, 178; and the new zoology, 5, 144-177; his many paintings, 5, 152; discoveries of numerous species of radiolarians, 5, 154; gastrula theory of, 5, 155; his theory of embryological development, 5, 156; great champion of Darwinism, *ibid.*; his work on morphology, 5, 157; liberty of spirit accorded at Jena, 5, 158; his laboratory at Jena, 5, 159; his method of work, 5, 161; his methods of teaching, 5, 163; recognized leader in the new zoology, 5, 171; his genealogical tree regarding the ancestry of man, 5, 172; man's line of descent clearly traced by, 5, 176.
- Haeckel, Ernst, and the New Zoology, Chapter VI, 5, 144.
- Hahnemann, Christian Samuel Friedrich, the medical system of, 4, 188.
- Hales, Stephen, father of vegetable physiology, 2, 298; study of the elasticity of air, 4, 11; described a process of distilling coal, 6, 207.
- Hall, Charles M., discovered a process for producing aluminum, 6, 300.
- Hall, Marshall, and physical diagnosis, 4, 203; observations and reflex action, 4, 251-258.
- Hall, Thomas, exhibited a small working-motor on a track forty feet long, 7, 179.
- Haller, Albrecht von, 4, 73-75; doctrine of irritability, 4, 74; discoveries in embryology, 4, 75; first to use the watch in counting the pulse, 4, 76.
- Halley, his observations on the changes in the variations of the compass, 3, 4; his observations on the transit of Mercury, 3, 5; his discovery of a method of determining the parallax of the planets, *ibid.*; calculated the orbit of a comet, 3, 6; speculations concerning meteors, 3, 7; showed that fixed stars have an actual or "proper" motion in space, 3, 57; showed that the deviations of the compass were due to some influence having to do with the problem of terrestrial magnetism, 7, 10.
- Hallidie, Andrew S., the first practical cable system made by, 7, 177.
- Halske, his experiments with electric motors, 7, 181.
- Haly, Abbas, author of *The Royal Book*, 2, 24.
- Hamilton, Charles K., his flight from New York to Philadelphia and return in June, 1910, 7, 298.
- Hamilton's, Sir William, collection acquired for British Museum, 5, 5.
- Hammer, a modified form of the lever, 6, 57.
- Hampson, Dr. William, improved method of liquefaction of gases, 5, 44; his apparatus for liquefying air, 5, 45.
- Hanaman, in connection with Just, takes out patent for a lamp with incandescent filament, 6, 235.
- Hand tools, modified forms of the lever, 6, 57-59.
- Hansen, Christian August, inventor of an electrical machine, 2, 274.
- Harets ben Kaladah, physician of Mohammed, 2, 23.
- Hargreaves, James, the first carding-machine invented by, in 1762, 9, 16; inventor of the spinning-jenny, 9, 21; first patent taken out in 1770, 9, 23; his description of his process of spinning, 9, 23; difficulties encountered in introducing his machine, 9, 24.
- Harrison, John, inventor of the first accurate watch, for which

GENERAL INDEX

- he received a prize of twenty thousand pounds sterling from the British Government, 7, 25.
- Hartley, Dr. David, his famous vibration theory, 4, 268.
- Harvey, From Paracelsus to, Chapter VII, 2, 156.
- Harvey, William, life of, 2, 169; his discovery of the circulation of the blood, 2, 171-178.
- Hatchet, principle of, 6, 54.
- Hauksbee, Francis, his mercurial fountain, 2, 250; discovery of "induction," 2, 250-262; early experiments with the telephone, 8, 67.
- Hauron, Ducos du, his simple method of color-photography, 8, 241.
- Hautefeuille, attempted to make practical use of the power set free by the explosion of gunpowder, 6, 134.
- Heat, Count Rumford's experiments with, 3, 209; Humphry Davy's independent demonstration that labor may be transformed into, 3, 255; Sadi Carnot expresses belief in the quantitative relation between work and, 3, 255; James Prescott Joule demonstrated the mechanical equivalent of, 3, 256; Colding, Mayer, and Helmholtz independently discover the same principle, 3, 257; Dr. Mayer's own account of his discovery, 3, 259; Joule's paper on, 1843, 3, 269; James David Forbes showed that radiant heat resembles light in its conformation to laws of polarization and double refraction, 3, 275; studies of heat by Professor William Thomson (later Lord Kelvin) led to the development of the doctrine of the dissipation of energy, 3, 276; the old theory of "imponderables" finally substituted by the theory of an all-pervading ether, 3, 281; explained as due to the vibrations of the particles of matter, 3, 294; studies of, by Clausius, Clerk-Maxwell, and others, led to the development of the kinetic theory of gases, 3, 295; absence of, causes liquefaction of gases, 3, 304; low-temperature researches in detail, 5, 38-72; principle that heat can do mechanical work by generating steam shown by Hero or Ctesibius, 6, 82; generation of, by electricity, 6, 169.
- Heat and Light, Modern Theories of, Chapter VI, 3, 206.
- Heating, the problem of, in ancient and mediæval dwellings, 9, 150; in skyscrapers, 9, 166.
- Heaviside, A. W., experimented with parallel telegraph lines, 8, 51.
- Heidenham, Dr. Rudolf, on the phenomena of hypnotism, 4, 269.
- Heliocentric theory, as propounded by Aristarchus in the third century B.C., 1, 212; as demonstrated by Copernicus in the fifteenth century A.D., 2, 54.
- Hellenistic Period, Greek Science of the Alexandrian or, Chapter IX, 1, 189.
- Helmholtz, Hermann von, his theory of solar energy, 3, 65; renounced all claim to the discovery of the conservation of energy in favor of Mayer, 3, 269; found that a vortex whirl once established in a frictionless medium must go on forever, 3, 290; his measurement of speed of nervous impulses, 4, 262; explanation of the continued heat of the sun, 5, 207; concluded that man would never be able to fly by his own power alone, 7, 278.
- Henderson, Thomas, his work at the Cape of Good Hope in

KEY AND INDEX

- detecting and measuring the parallax of a star, **3**, 61.
- Henry III, French King, his use of extraordinary ruffs, **9**, 65.
- Henry VIII, probably introduced knitted stockings into England, **9**, 68.
- Henry, Joseph, his experiments with electric magnets, **3**, 239; **8**, 16; his early studies of electro-magnetic induction, **6**, 175; his construction of electro-magnets, **6**, 177.
- Henry the Navigator of Portugal, his physicians credited with inventing or introducing the astrolabe, **7**, 19.
- Henson, his studies of the lifting-power of plane surfaces, **7**, 246.
- Heraclides first to point out the value of opium in certain diseases, **1**, 196.
- Hero, or Heron, a pupil of Ctesibius, **1**, 243; an explicit champion of the molecular theory of matter, **1**, 245; his experiments with water and gases, **1**, 246; his experiments with heated air to produce motor power, **1**, 247; his experiments with air under pressure, **1**, 248; his steam engine, **1**, 250; the inventor of the penny-in-the-slot machine, **1**, 251; studied phenomena of suction, **6**, 64; described and perhaps invented mechanism to show that heat could do mechanical work, **6**, 82.
- Herodotus, his visit to Babylon, **1**, 57, 103; refers to the use of skins in writing, **8**, 110.
- Herophilus, his records are the first we have of the dissection of the human body, **1**, 194; handed condemned criminals over to the medical profession to be operated on, **1**, 195.
- Herschel, John, in collaboration with James South he discovered many double stars, **3**, 58; his improvements of the microscope, **4**, III.
- Herschel, William, his positive genius for sidereal discovery, **3**, 19; discovered the planet Uranus, **3**, 20; conceived the universe to be a vast galaxy of suns held to one centre, **3**, 22; thinks that all the suns are "well supplied with inhabitants," **3**, 23; theory of the Milky Way, **3**, 24; thought all the suns of a system would be drawn together and destroyed by impact, **3**, 26; suggests that the planets Ceres and Pallas be called asteroids, **3**, 41; discovered that certain fixed stars have changed their relative positions, **3**, 57.
- Hertz, Dr. Heinrich, discovered the method now used in wireless telegraphy, **3**, 247; his electro-magnetic theory of light, **3**, 280; produced electromagnetic waves, **6**, 154; discovery of "Hertzian" waves, **8**, 52.
- Hevelius, Johannes, advanced astronomy by his accurate description of the face and the spots of the moon, **3**, 3.
- Hesse, G. Emil, description of the Svea caloric engine, **6**, 145.
- Hewitt, Peter Cooper, his invention of the mercury-vapor light, **6**, 236.
- High temperatures, obtained by electricity, **6**, 314; obtained by explosion of cordite in closed chamber, **6**, 315.
- Highway of the Waters, The, Chapter II, **7**, 56.
- Hildanes, Fabricius, German surgeon, **2**, 183.
- Hinrichs, Professor Gustav, draws attention to "law of octaves," **4**, 67.
- Hipparchus, demonstrated the eccentricity of the sun's seeming orbit, **1**, 234; his theory, though incorrect, absolutely consistent with all the facts of a correct observation of the sun's eccentricity, **1**, 235; his

GENERAL INDEX

- theory exemplified by a lantern on a cart-wheel, **1**, 237; the dominant scientific personality of his century, **1**, 238; demonstrated the precession of the equinoxes, **1**, 242.
- Hippocrates, the "father of medicine," **1**, 174; his speculations about the heart, **1**, 175; his acceptance of the *humoral* theory of disease, **1**, 176.
- Hirschovel, early English potter who produced wares of superior quality, **9**, 232.
- Histological scheme, the, of Gerlach, **4**, 281.
- Histology, the rise of, **4**, 113.
- History, Natural, to the Time of Linnæus, Chapter XV, **2**, 297.
- Hoe, a modified form of the lever, **6**, 57.
- Hoe, Richard M., inventor of the type-revolving machine, **8**, 127.
- Hofer, H., German experimenter, proved that nitrogen from the air can be made to combine with oxygen in the laboratory, **6**, 306.
- Hoffman, Mr., invented a rotary engine, **6**, 123.
- Hoffmann, Friedrich, arranged Boerhaave's doctrines in a "system," **4**, 184.
- Holland, the type of diving-boat most familiar to the majority of people, **7**, 107.
- Holland, Philemon, his translation of the summary of Babylonian science by Diodorus, **1**, 77.
- Holland, P., success of the submarine due to his efforts, **7**, 105; the Holland type of boat, **7**, 107.
- Holmes, Sir George, his description of the voyage of the replica of the *Santa Maria*, **7**, 60.
- Honain ben Isaac, Arabian physician, **2**, 24.
- Honorius, public mills probably introduced in the Roman Empire about the time of his reign (384-423 A.D.), **6**, 71.
- Hooke, Robert, **2**, 215; his flying-machines, **2**, 216; microscopical observations, **2**, 217, 218; controversy with Newton, **2**, 237; prone to claim other men's discoveries, **8**, 23; method of communication by telephone, **8**, 68.
- Hooker, Sir Joseph, half-convert to Darwin's views, **4**, 171; accepts Darwin's theories, **4**, 174.
- Hopkins' estimate of the thickness of the earth's crust, **5**, 212.
- Hopkins and Rittenhouse invented and sent up a balloon, **7**, 237.
- Hornblower, Jonathan, invents and patents compound engine; the original element in his idea, **6**, 117.
- Horse, the worker *par excellence*, domestic use of, **6**, 59.
- Horse-power, origin of term, **6**, 60.
- Hot Air Engine, Dr. Stirling's efforts to invent, **6**, 133; limitations of, **6**, 134; John Ericson's development of, **6**, 134; calorific engine of Svea, **6**, 145.
- Houghton, George C., his description of the modern shoe industry, **9**, 108.
- Housatonic, the sinking of, by a submarine, **7**, 103; the attack described, **7**, 104.
- Howard, Luke, his paper on clouds, **3**, 182; his views concerning the formation of dew, **3**, 183.
- Howe, Elias, Jr., invents the practical commercial sewing-machine, **9**, 93; struggles of the inventor and final triumph, **9**, 95.
- Hudson, Henry, his heroic effort to find the fabled northwest passage, **7**, 47.
- Hughes, Prof. D. E., his independent invention of a coherer of service in wireless telegra-

KEY AND INDEX

- phy, 8, 53; invents a telephone transmitter 8, 84.
- Hughlings-Jackson, Dr., studies of epilepsy, 4, 272.
- Hugon, M. P., gas engine of, 6, 136.
- Hulls, Jonathan, patented a marine engine, 7, 66.
- Humboldt, Alexander, his memoir on isothermal lines and the distribution of heat, 3, 192; made practicable a truly scientific study of comparative climatology, 3, 194; called our atmosphere an "aerial ocean," 3, 195; his theories about the Gulf Stream, 3, 196.
- Hunnings, inventor of the first long-distance transmitter, 8, 84.
- Hunt, Walter, inventor of a sewing-machine using a needle with the eye near the point, 9, 92.
- Hunter, John, physiologist and surgeon, 4, 78; his discovery of lymphatics, 4, 80; his discovery of the "collateral circulation" of the blood, 4, 82; his operation for aneurism, 4, 84; surgeon-extraordinary to the king, 4, 86; his theories of the action of gastric juices, 4, 89; proved the action of digestive fluid after death, 4, 90, 91.
- Hunter, William, physician and anatomist, 4, 77; his love of controversy, 4, 78.
- Hutton, Dr. James, claimed that the face of nature is undergoing metamorphic changes, 3, 118; the bases of the present continents were being laid in ancient sea beds, 3, 119; the agency which solidified the ocean beds is subterranean heat, 3, 120; the destruction of our land inevitable, 3, 122; marks of marine animals in solid parts of the earth, 3, 124; the elevation of the land above the water was caused by the expansion of heated matter, 3, 128; finds no vestige of a beginning—no prospect of an end, 3, 129; his theories hostile to sacred history, 3, 130; his theories accepted, 3, 140; his theory concerning the vapor of water, 3, 178.
- Huxley, Thomas Henry, reviews the work of Professor Marsh, 3, 112; accepts Darwin's theory 4, 174; his estimate of Darwin's accomplishments, 4, 178.
- Huygens, Christian, 2, 218; improvement of the telescope, 2, 218, 219; his laws of motion, 2, 222; "pneumatical experiments," 2, 222; a resident of France, 2, 224; his micrometer, 2, 254; application of coiled balance-spring to watches, 2, 256; originator of the general doctrine of undulation as the explanation of light, 3, 224; gave the first hint of the existence of ether, 3, 284; attempted to make practical use of the power set free by the explosion of gunpowder, 6, 134.
- Hydrochloric acid liquefied, 5, 40.
- Hydrogen, liquefied by Professor Dewar, 5, 43; approach to the absolute zero made by, 5, 69.
- Hydrophobia, Pasteur's inoculations to prevent, 4, 240; slow in manifesting itself, 5, 182.
- Hydrostatic press, principle of, 6, 74-75.
- Hygiene, investigations in, at the Berlin Institute, 5, 196.
- Hypnotism, phenomena of, 4, 269.
- IATROCHEMICAL school of medicine, 2, 186.
- Iatrophysical school of medicine, 2, 187.
- Illustrations, the reproduction of, 8, 184; wood-engraving,

GENERAL INDEX

- 8, 184; copper- and steel-plate engravings, 8, 192; etching, 8, 195; mezzotint, 8, 196; the invention of lithography, 8, 197; introduction of process work, 8, 202; discovery of photography by Daguerre, 8, 202; the half-tone, 8, 205; three-color process of reproduction, 8, 211; intaglio processes, 8, 217; the photogravure, 8, 217.
- Imhôtep, the demi-god, considered to be the creator of medical knowledge, 1, 49.
- Imperial Academy of Sciences at St. Petersburg, 2, 202.
- Inclined plane, known to antiquity, principle of, use in pyramid-building, 6, 37; law of, screw and wedge a form of, 6, 38; hatchet, knife-blade, and saw, forms of, 6, 54-55.
- Induction, electric, discovered by Hauksbee, 2, 259-262.
- Inductive versus deductive reasoning, 5, 235-238.
- Industrial problems of to-day and to-morrow, 6, 316.
- Industrial Revolution, An, Chapter I, 9, 5.
- Inorganic matter, possibilities of, 5, 224.
- Insane, reforms in caring for, 4, 245.
- Instruments of Precision in the Age of Newton, Chapter XIII, 2, 252.
- Iron Age, 6, 9.
- "Isomerism," word coined by Berzelius, 4, 62.
- Italic leaders of thought, Xenophanes, Parmenides, and Empedocles, 1, 114.
- Ives, F. E., perfected the process of color-printing, 8, 212; invented a slide-carrier for the camera, 8, 238.
- JABLOCHKOFF, M., Russian officer who invented a practical electric light, 6, 224.
- Jacobs, a Dutch farmer whose children first found diamonds in South Africa, 9, 314.
- Jackson, Dr. Charles T., claimed the discovery of ether, 4, 215; his interest in the possibilities of electricity, 8, 19; discusses the telegraph with Morse; contests Morse's claim to the invention of the telegraph, 8, 21; Sabine's summary of the position of Doctor Jackson, 8, 21.
- Jacquard, the aerial voyage of the, 7, 260.
- Jacquard, Joseph Marie, inventor of a loom for weaving elaborate patterns, 9, 49; early life of the inventor, 9, 49; his machines destroyed by mobs of workmen, 9, 51.
- Jaegels, his ascent in a metal balloon, 7, 264.
- Janney, Eli, automatic car-coupler invented by, 7, 148; technical description of this coupling, 7, 149.
- Jansen, Zacharias, inventor of the microscope, 2, 77.
- Jansen, photographic revolver invented by, 8, 250.
- Jeffries, made a daring balloon ascension with Blanchard, 7, 239.
- Jena, the "dream city," 5, 145; the streets of, 5, 146; the market-place of, 5, 147; its world-renowned university, 5, 148.
- Jenner, his discovery of inoculation for preventing small-pox, 4, 190; his famous paper on vaccination, 4, 194; his first inoculation, 4, 196; reception of the discovery in Europe, 4, 197.
- Jenny, architect who designed the first steel-frame skyscraper in 1884, 9, 165.
- Jessop, William, substituted flanged wheels for flanged rails, 7, 120.
- Jet-stone, supposed to possess a magical property that would

KEY AND INDEX

- cure epilepsy, hysteria, and gout, **1**, 277.
- John Mason*, the, an omnibus horse-car operated on the first street railway, **7**, 176.
- Joly, Dr. Robert, first screen-plate process in color-photography put forward by, **8**, 242; description of his plates, **8**, 242.
- Jones, Chapman, method of color-photography outlined by, **8**, 247.
- Joseph and Roderick, and Martin de Bohemia, credited with inventing the apparatus known as the astrolabe, **7**, 19.
- Jouffroy, Marquis de, experiments with steam-propelled boats, **7**, 66.
- Joule, James Prescott, the work of, **3**, 256; his theory of the conservation of energy, **3**, 257; his paper of 1843, **3**, 269; his theories on the calorific effect of magneto-electricity and the mechanical value of heat, **3**, 270.
- Julian calendar, it follows the Alexandrian theory, giving us the familiar leap-year, **1**, 36.
- Julien, E., the storage-battery line built by, **7**, 188.
- Julius Caesar, water mills probably introduced in Rome during time of, **6**, 70.
- Jupiter, its moons discovered by Galileo, **2**, 79.
- Just, in connection with Hanaman, patented a lamp using incandescent filament, **6**, 235.
- KADMUS, a Phœnician, who, according to a Greek legend, brought the knowledge of letters to Europe, **1**, 86.
- Kaiser Wilhelm II.* and *Deutschland*, German ships that for several years held the ocean record for speed, **7**, 82.
- Kant, Immanuel, his conception of the formation of the world, **3**, 26; his theories of the solar system, **3**, 27; defects in his conception, **3**, 30; and transmutation of species, **4**, 149.
- Kay, John, inventor of the flying shuttle, **9**, 42; what his invention meant to the commercial world, **9**, 42.
- Kay, Robert, inventor of the "drop-box" used in weaving, **9**, 43.
- Kelly, William, invented a method of running the spinning-mule by water-power, **9**, 35.
- Kelvin, Lord, his theory of the developmental changes of the earth, **3**, 165; he endorses Joule's theories on the conservation of energy, **3**, 272; his doctrine of the dissipation of energy, **3**, 276; declared that he had learned nothing new concerning the nature of energy in fifty years, **3**, 279; his speculation about ether, **3**, 288; his doctrine of the vortex theories of atoms, **3**, 290; his estimate of the size of the molecules floating in the air, **3**, 298; theories of radio-activity, **5**, 106; explanation of the continued heat of the sun, **5**, 207; estimate of the heat-giving life of the sun, **5**, 208; computations as to the age of the earth's crust, **5**, 210; computations of the rigidity of the telluric structure, **5**, 212; inventor of the modern compass, **7**, 14; his connection with the laying of the Atlantic cable, **8**, 30; ultimate success of cable-laying in a large measure due to his inventions, **8**, 33; invents the mirror-speaking instrument, or "marine galvanometer," **8**, 38; invention of the siphon recorder, **8**, 45.
- Kepler, Johann, life and work, **2**, 70; theory of planetary distances, **2**, 73; assistant of Tycho Brahe, **2**, 74; Kepler's Laws, **2**, 75; studies of re-

GENERAL INDEX

- fraction of light, 2, 118;
Keplerian telescope, 2, 253.
- Kertland, Philip, began the manufacture of shoes at Lynn, 9, 108.
- Khammurabi, Babylonian king, his famous code concerning physicians, 1, 76.
- Kirchhoff, with Bunsen, perfected the spectroscope, 4, 69.
- Kitasato, Professor, his studies in the embryos of fishes, 5, 132.
- Knife-blade, a modification of the inclined plane, principle of, 6, 54.
- Knitting-machinery. See Textiles.
- Knowledge, Natural, The Royal Society of London for Improving, Chapter II, 5, 14.
- Koch, Dr. Robert, corroboration of Devaine's discovery, 4, 228; work of, in the Berlin Institute of Hygiene, 5, 194.
- Koenig, Friedrich, his manometric capsules of use to Graham Bell in his experiments with the telephone, 8, 78; practical solution of cylinder press credited to, 8, 123.
- Kowalski, Professor, experimented unsuccessfully in commercial extraction of nitrogen from the air, 6, 306.
- Kratzenstein, Christian Gottlieb, used electricity in medical practice, 2, 278.
- Krayne, Robert, his method of making line color-screens, 8, 242.
- Krebs and Renard, invented *La France*, a motor-driven balloon, 7, 264.
- Krüger, Gottlieb, suggests the medicinal use of electricity, 2, 278.
- Krupp steel, its introduction and important uses, 6, 295.
- Krypton, discovery of, 5, 87.
- Kunz, George F., his striking illustration of the power of radium, 5, 101.
- Kuzel, one of the experimenters with incandescent filament lamps, 6, 235.
- LABOR, physical, modern attitude toward; always distasteful to mankind, considered a disgrace and a curse by ancient philosophers; avoidance of, by the more intelligent of mankind, 6, 26; task of science to reduce, 6, 28.
- Laboratory, The Marine Biological, at Naples, Chapter V, 5, 113.
- Laboratories, Physical, and Physical Problems, Chapter IV, 5, 73.
- Laboratories, Some Medical, and Medical Problems, Chapter VII, 5, 178.
- Laborde, M., his theories of radio-activity, 5, 106.
- Labouchère, flew for ten minutes with two passengers at Mourmelon, 7, 298.
- Lace-making. See Textiles.
- Ladd, constructed dynamo-electric machines, 6, 178.
- Laënnec, René Théophile Hyacinth, his invention of the stethoscope, 4, 201; his *Traité d'Auscultation Médiate*, 4, 202.
- La France*, motor-driven balloon of Renard and Krebs, 7, 264.
- Lake, Simon, invented practical diving-boats, 7, 107.
- Lallament, Pierre, a bicycle invented by, 7, 155.
- Lamarck, Jean Baptiste, a student of fossil shells about Paris while Cuvier was studying the vertebrates, 3, 93; his advocacy of a theory of organic evolution, 4, 150; his theories formulated in the important work *Philosophie Zoologique*, in 1809, 4, 152.
- Lambert, Professor, his estimate of the gyroscope, 7, 224.
- Lamp, burning oil, as used in ancient times, 6, 202; a

KEY AND INDEX

- broad flat wick for, invented by Leger, in 1783, **6**, 204; adaptation of the Argand form of burner, **6**, 205; of Quinquet, **6**, 205; Carcel's improvement of Quinquet's lamp, **6**, 205; using turpentine and known as "Camphine" lamp, **6**, 206; modern petroleum lamps introduced, **6**, 206; Safety, of Sir Humphry Davy, **6**, 249.
- Lane-Fox, an early experimenter with electric light, **6**, 228.
- Langen, Herr E. (with N. A. Otto) made important improvement in piston arrangement of gas engine, **6**, 136.
- Langley, his early experiments and discoveries, **7**, 275; the flying-machine of, **7**, 284.
- Lanston, Tolbert, monotype machine invented by, **8**, 145.
- Laplace, Pierre Simon, Marquis de, removed the last doubts as to the solidarity of Newtonian hypothesis of universal gravitation, **3**, 31; his explanation of the planetary system, **3**, 32; his conception as to the formation of suns and stars, known as the "nebular hypothesis," **3**, 35; his reasoning about the ring of Saturn, **3**, 38; he thinks comets are strangers to our planetary system, *ibid.*; explains why the movements of comets escape this general law, **3**, 39; thought that the rings of Saturn were solid, **3**, 44.
- Lartet, Edouard, his discovery of fossils in the caves of Dordogne, **3**, 104.
- Latham, Hubert, his attempt to fly across the English Channel, **7**, 294.
- La Tour, Cagniard, discovered pepsin in the gastric juice, **4**, 129; studies of micro-organism, **4**, 218.
- Latitude, measuring a degree of, **7**, 34.
- Laudanum, its introduction, **2**, 190.
- Lavoisier, Antoine Laurent, the founder of modern chemistry, **4**, 28-36; first blow to the phlogiston theory, **4**, 31; experiments in respiration, **4**, 93.
- Law of Gravitation, Newton and the, Chapter XI, **2**, 236.
- Law of valency, **4**, 63.
- Lawson, H. J., the geared bicycle introduced by, **7**, 155.
- Layard, Sir Henry, his excavations on the site of ancient Nineveh brought to light a most important collection of tablet books, **8**, 103; for fuller account of these documents see **4**, 292.
- Lea, Cary, improved the colloidion-emulsion process, **8**, 232.
- Leblanc, Abbé, constructed an instrument for reproducing the human voice, but which failed as a sound-producer, **8**, 94.
- Lebon, Frenchman who early experimented with illuminating gas, **6**, 207.
- Le Bris, the flying-machine of, **7**, 248.
- Lee, Rev. William, inventor of the knitting-machine, **9**, 56.
- Leeuwenhoek discovers bacteria, **2**, 179.
- Leger, a new type of burner and wick for the oil lamp invented by him in 1783, **6**, 204.
- LeGray, glass negatives improved by, **8**, 229.
- Leibnitz, Gottfried Wilhelm, estimate of his work, **2**, 197; theory of monads, **2**, 198; president of the Royal Academy of Sciences at Berlin, **2**, 202.
- Leidy, Joseph, found the cysts of trichina in pork, **4**, 207; one of the chief explorers of the fossils-beds of America, **3**, 106; at least a tentative believer in evolution before Darwin's exposition of the origin of species, **4**, 166.

GENERAL INDEX

- Lenoir, J. J. E., inventor of the first practical gas engine, **6**, 135.
- Leonardo da Vinci, **2**, 47; denial of the sun's motion, **2**, 48; his steam-engine, *ibid.*; his camera obscura, *ibid.*; his geological observations, **2**, 50; gave new impulse to mechanical invention; produces earliest type of explosion engine, **6**, 83; made sketches and possibly models of flying machines, **7**, 227.
- Lepsius, Karl Richard, extended the study of the famous trilingual inscriptions of the Rosetta Stone, **1**, 27; determined that the ancient stadium was one hundred and eighty meters, **1**, 231.
- Le Sage, George Louis, his theory of gravitation, **5**, 214.
- Leupold, his non-condensing high-pressure engine, **6**, 112.
- Levassor, M. (with M. Panhard), invented a modern gasoline motor, **6**, 140; applied the Daimler motor to four-wheeled vehicles and thus developed the automobile, **7**, 157.
- Levy, Dr. Max, invented a machine for making half-tone illustrations, **8**, 207.
- Lewes, George Henry, his translation of Ritter's rendering of part of the poem of Parmenides concerning the origin of man, **1**, 131.
- Lever, principle of, modifications of, **6**, 20; laws of, credit of discovering given to Archimedes, three classes of, **6**, 30; modified forms of, in hand tools, **6**, 57.
- Leyden jar, invention of, by Von Kleist, **2**, 280.
- Liebermann, effected the synthesis of alizarine, **8**, 313.
- Liebig, Justus, isomerism proved by, **4**, 62; school of physiological chemistry, under guidance of, **4**, 128; his studies of animal heat, **4**, 131-135; his doctrine of fermentation, **4**, 219.
- Light, heat, and atmospheric pressure, **2**, 117.
- Light, Modern Theories of Heat and, Chapter VI, **3**, 206.
- Light, Newton and the Composition of, Chapter XI, **2**, 225.
- Light, the wave theory of, Thomas Young and, **3**, 215-225; endorsed by Fresnel and Arago, **3**, 226; opposition to, *ibid.*; accepted by French Academy, **3**, 227.
- Lighting, Artificial, Chapter XI, **6**, 201.
- Lighting Artificial, the use of the torch by primitive man, **6**, 202; lamps used in ancient times, **6**, 202; lamps used by the Greeks and Romans, **6**, 203; by Gas, **6**, 207; early experiments by Rev. Joseph Clayton, and Dr. Stephen Hales, **6**, 207; the possibility of using gas for illumination demonstrated by William Murdoch, in 1798, **6**, 207; the incandescent gas mantle, **6**, 208; the introduction of acetylene gas, **6**, 212; Davy and the first electric light, **6**, 220; the Jablochkoff candle, **6**, 223; Brush's improved arc light, **6**, 226; Edison and the incandescent lamp, **6**, 228; tungsten and tantalum lamps, **6**, 234; the mercury-vapor light of Hewitt, **6**, 236.
- Lightning, proved to be electricity by Franklin, **2**, 293; amount of electricity generated by, **6**, 161.
- Lightning-rod, invented by Benjamin Franklin in 1750, **2**, 290.
- Lilienthal, Otto, the flying machine of, **7**, 279.
- Lilly, associated with Dr. Colton in the construction and operation of a small model locomotive, **7**, 179.

KEY AND INDEX

- Lime-light, method of producing, **6**, 209.
- Linde, Professor, improved method of liquefaction of gases, **5**, 44.
- Linnaeus, Natural History to the Time of, Chapter XV, **2**, 297.
- Linnaeus, Carolus, member of Royal Swedish Society **2**, 203; life and work, **2**, 299-303.
- Lippershey, Johannes, inventor of the telescope, **2**, 78, 252.
- Lippmann, Prof. Gabriel, proposed a direct method of color-photography, **8**, 237; devised a method of employing the minute spectra of prisms, **8**, 246.
- Liquefaction of gases, **5**, 40-46; improved methods of, **5**, 44; principles and experiments, **5**, 46-60; results and anticipations of the, **5**, 61-72; use of, in the refrigeration of foods, **5**, 61.
- Liquefied air, **5**, 45, 46, 63-67.
- Liquid chlorine, Faraday produces, **5**, 39.
- Liquid Fuel, **7**, 90; its advantages over coal, **7**, 91; its disadvantage, **7**, 91.
- Lister, Joseph Jackson, experiments with the microscope, **4**, 112; studies of lenses, **4**, 113; shape of the red corpuscles settled by, **4**, 114.
- Lister, Dr. Joseph (Lord Lister), discovery of antiseptis, **4**, 229; and surgery, **4**, 231; president of the Royal Society of London, **5**, 16.
- Lithography, invented by Alois Senefelder, **8**, 198; materials used in, **8**, 199.
- Liver, the important share of, in preparing food for absorption, **4**, 130; not a ductless organ, **4**, 137; blood undergoes a change in passing through, **4**, 138; cells, *ibid.*
- Living forms, question as to, on other worlds, **5**, 220.
- Lockyer, Sir Norman, his "meteoric hypothesis," **3**, 70; does not meet with unanimous acceptance, **3**, 71; his deductions from observations of the sun and stars through the spectroscope, **4**, 71; spectroscopic study of sun and stars, **5**, 73; his theories, **5**, 75; study of sun-spots, **5**, 76; studies of the reverse lines of spectrum, **5**, 78; studied the spectrum of the new star that appeared in the constellation Perseus in 1901, **5**, 79.
- Locomotive, mining, **6**, 257. (See "steam locomotive.")
- Lodge, Sir Oliver, and the instability of the atom, **5**, 109; experiments of, **8**, 53.
- Log, the use of, on ships, **7**, 16.
- Logical induction versus hasty generalization, **5**, 239-242.
- Lome, Dupuy de, the dirigible balloon of, **7**, 263.
- Long, Dr. Crawford W., claim to the discovery of ether, **4**, 215.
- Long-distance telephone, **8**, 84.
- Longitude, method of ascertaining, **7**, 31.
- Loom, development of the power-loom, **9**, 43; the power-looms suggested by the Frenchmen, de Gennes and Vauconson, **9**, 43; practical loom invented by Dr. Edmund Cartwright, **9**, 44; events leading up to the invention of the power-loom, **9**, 45; the perfected power-loom, **9**, 48; the Jacquard loom, **9**, 49; the Northrop loom, **9**, 51.
- Lotze, Dr. Hermann, his *Medizinische Psychologie, oder Physiologie der Seele*, **4**, 263.
- Louis, the "statistical method" introduced by, **4**, 203.
- Louis XIV, his practical joke on Charles II, **9**, 62.
- Lovejoy, in association with Bradley experimented with the commercial extraction of nitrogen, **6**, 306.

GENERAL INDEX

- Low-Temperature Researches, The Royal Institution and the, Chapter III, 5, 29.
- Low temperature, experiments with, 5, 39-41; electrical and magnetic conditions at, 5, 56; changes in color of substances at, 5, 57; substances made luminous by, 5, 58; effect of, upon the strength of materials, 5, 59; decrease of chemical activity at, 5, 60; approach to the absolute zero, 5, 69.
- Lubbock, Sir John (later Lord Avebury), a recruit to the Darwinian theory, 4, 175.
- Ludolf, Christian Friedrich, experiment with the electric spark, 2, 276; 6, 219.
- Lumiere, Auguste, his work in color-photography, 8, 243.
- Lumiere, Louis, his work in color-photography, 8, 243.
- Lure of the Unknown, The, 7, 45.
- Lusitania, description of turbine engines of, 6, 128; in size and speed marks an epoch in navigation, 7, 82.
- Lyell, Sir Charles, repudiated all thought of catastrophism, 3, 88; he adopted and extended the Huttonian doctrine, 3, 92; his theories are changed by Darwin's *Origin of Species*, 3, 97; claimed that past changes of the earth's surface have been like present changes, 3, 141; accepts Darwin's theory, 4, 174.
- Lyncean Society, 2, 200.
- McDonald, Arthur, his automobile record at Ormonde, 7, 165.
- McDonough, J. W., produced a practical screen-plate, 8, 242.
- McKay, inventor of a machine for sewing leather, 9, 112.
- MacMillan, Kirkpatrick, treadle bicycle invented by, 7, 155.
- Magdeburg sphere, name given to Von Guericke's apparatus for showing atmospheric pressure, 2, 211; 6, 66.
- Magellan, Ferdinand, rounded the southern point of South America and reached the Philippines, in 1521; the circumnavigation of the globe by his ships afforded an unchallengeable demonstration of the rotundity of the earth, 7, 47.
- Magendie, François, and physical diagnosis, 4, 203.
- Magnet, electric, first constructed by Sturgeon, 6, 176; constructed by Joseph Henry, 6, 177; an essential element of the practical dynamo, 6, 174, 180.
- Magnetism, The Modern Development of Electricity and, Chapter VII, 3, 229.
- Magnetism, studies of, by Oersted, 6, 176.
- Magnetized needle, constitutes the mariner's compass, 7, 7.
- Majestic, one of the first twin-screw boats to make ocean-records, 7, 81.
- Malpighi, Marcello, demonstrated passage of blood from arteries to veins through capillaries, 2, 178; dissections of animal tissues and plants, 2, 297, 298.
- Mammalian types, the living fauna of Australia to-day existed in Europe and died out in the tertiary age, 3, 160.
- Man, struggles with nature, 6, 3-6; the tool-making animal, 6, 6-8; characterized by nature of his implements, 6, 8-9; emancipated from thralldom of weather by clothing and fire, 6, 10; becomes agriculturist, 6, 11; the ever-insistent problem of his existence, 6, 12; performs work by muscular system alone, 6, 53.
- Mantle, gas, method of making, 6, 211; use of collodion and castor oil for strengthening, 6, 211; Clamond method of manufacture, 6, 212.

KEY AND INDEX

- Manufacturing**, methods at beginning nineteenth century compared with those at end, **6**, 21-22.
- Marchettis**, Peter, Italian surgeon, **2**, 185.
- Marconi**, Guglielmo, first to succeed in transmitting wireless messages across the ocean, **8**, 54; methods and results of his system, **8**, 56; his early experiments, **8**, 58; first trans-Atlantic message, **8**, 61.
- Marconnet**, Captain, and Lieutenant Fegaunt made a cross-country flight on a Farman bi-plane, June, 1910, **7**, 298.
- Marey**, Stephen, his interest in the development of chronophotography, **8**, 250.
- Mariette**, Auguste Edward, a worker in the field of Egyptian archaeology, **1**, 28.
- Marine Biological Laboratory at Naples**, The, Chapter V, **5**, 113.
- Marine Biological Laboratory at Naples**, the aquarium in, **5**, 113-119; arrangement of tanks and exhibits in, **5**, 114; eels and cuttle-fish in, **5**, 116; the octopus in, **5**, 117; the technical department of, **5**, 120; Dr. Anton Dohrn, founder of, **5**, 121; his associates, **5**, 122; collecting specimens for, **5**, 123, 124; methods of preserving jellyfish in, **5**, 127; many nationalities represented among the workers in, **5**, 130; Dr. Driesch's studies of heredity at, **5**, 131; the study of chromosomes at, **5**, 133; experiments in the division of egg-cells at, **5**, 134; publications of, **5**, 139; marine laboratories of other countries, **5**, 143.
- Mariner's Compass**, **7**, 7; consists of a magnetized needle, **7**, 7; its use antedates the Christian Era, **7**, 7; development of **7**, 8; Stephen Burrows credited with the discovery that the needle shifts its direction, **7**, 9; Dr. Halley showed that the deviations of the compass were due to some influence having to do with the problem of terrestrial magnetism, **7**, 10; Graham discovered daily variations of the compass, **7**, 10; Wales observed fluctuation of the compass due to the ship on which it is placed, **7**, 11; Matthew Flinders discovered that the influence of the ship over its compass varies with the direction of the ship's prow, **7**, 11; Barlow suggested that compensation for deviation of the compass be effected by the adjustment of bodies of iron, **7**, 11; Professor Airy's use of permanent magnets to effect compensation, **7**, 11; dipping of the magnetized needle first observed by Robert Norman, **7**, 13; attempt to overcome the dip by applying a balancing apparatus, **7**, 14; modern compass invented by Lord Kelvin, **7**, 14.
- Marine Galvanometer**, invented by Lord Kelvin, **8**, 38.
- Mariotte**, Edme, studies of atmospheric pressure, **2**, 210; developed law of gaseous pressure independently of Boyle, **6**, 66.
- Marsh**, Professor, his discovery of the remains of many vertebrates in the Rocky Mountain region, **3**, 106; his description of the fossil horses, **3**, 108.
- Marsh**, quoted to the effect that rust helps preserve iron embedded in concrete, **9**, 198.
- Martainville**, suggested a change in the shape of the envelope of the balloon, **7**, 248.
- Martin de Bohemia**, and Roderick and Joseph, credited with inventing the apparatus known as the astrolabe, **7**, 19.

GENERAL INDEX

- Martin, Thomas Commerford**, quoted in reference to electrical motors, **7, 179**.
- Maskelyne, Nevil**, astronomer royal who antagonized Harrison the watchmaker, **7, 32**.
- Maspero, Gaston Camille Charles**, a student of Egyptian archaeology, **1, 28**; held that the epagomenal days were in use before the first Thinite dynasty, **1, 36**.
- Masson, M.**, French physicist who explained the source of incandescence in electric light, **6, 223**.
- Matter, The Ether and Ponderable**, Chapter IX, **3, 283**.
- Matthews, American planter** who became a shoe manufacturer as early as 1648, **9, 109**.
- Maupertius and the idea of the transmutation of species**, **4, 149**.
- Mauretania**, British ship which in size and speed marks an epoch in navigation, **7, 82**.
- Maurey**, invented an improvement upon the phonograph, **8, 79**.
- Maurice, Prince of Orange**, a passenger in the extraordinary wind-propelled vehicle of Servinus, **6, 68**.
- Maury, M. F.**, his theory as to the causes of the Gulf Stream, **3, 196**.
- Maxim, Sir Hiram**, the flying machine of, **7, 283**.
- Mayer, Dr. Julius Robert**, his paper on "The Forces of Inorganic Nature," **3, 259**; asserts that a force once in existence cannot be annihilated, **3, 263**; gave for the first time a tenable explanation of the light and heat of the sun and stars, **3, 268**; his explanation of the continued heat of the sun, **5, 206**.
- Mayer, Johann Tobias**, German astronomer whose tables of great value to the navigator were published in 1753, **7, 30**.
- Mayow, John**, experiments with air, **4, 6**.
- Mediæval Science Among the Arabians**, Chapter II, **2, 13**.
- Mediæval Science in the West**, Chapter III, **2, 31**.
- Mediæval Ships**, **7, 59**.
- Medical Laboratories and Medical Problems**, Some, Chapter VII, **5, 178**.
- Medicine**, associated with charms and incantations as practised in ancient Egypt, **1, 46**; equally so in Babylonia-Assyria, **1, 70**; the code of Khammurabi throws light on the methods of the physician of ancient Babylonia, **1, 76**; in Greece, before the time of Hippocrates, a mixture of religion, necromancy, and mysticism, **1, 170**; the sick were carried to temples of the god of medicine, Æsculapius, and took remedies revealed to them in dreams of the god, **1, 171**; many of the wealthy Greek physicians had dispensaries, **1, 173**; Hippocrates and his reforms, **1, 174**; Alexandrian medicine, **1, 194**; Galen and Roman medicine, **1, 272**; Arabian medicine, **2, 21**. For the development of medicine from the sixteenth century to the present time, see the preceding reference and the three succeeding ones. See also the chapters on physiology.
- Medicine in the Sixteenth and Seventeenth Centuries**, Chapter VIII, **2, 181**.
- Medicine, Eighteenth-Century**, Chapter VII, **4, 182**.
- Medicine, Nineteenth-Century**, Chapter VIII, **4, 199**.
- Mees, Dr.**, outlines the probable future of color-photography, **8, 247**.
- Mena**, king of Egypt, **1, 28**

KEY AND INDEX

- Menant, Joachim**, on the development of a rudimentary science of natural history among the Babylonians, **1, 75**.
- Mendeleeff, Dmitri**, attention drawn to the "law of octaves," which he elaborated into a famous system, under title of the "periodic law," **4, 68**.
- Mercator, Gerardus**, brought the art of map-making to perfection, **7, 30**.
- Mercury-Vapor light**, **6, 236**.
- Mergenthaler, Ottmar**, the linotype machine invented by, **8, 142**.
- Mesopotamia**, named by the Greeks, **1, 56**; its civilization fully on a par with that of Egypt, **1, 59**; its earliest inhabitants were an alien race, **1, 60**; the scientific attainments of its inhabitants, the Babylonians and Assyrians, **1, 61-85**.
- Metamorphosis of parts**, **4, 140**; Goethe studies of, in plants, **4, 140, 45**; extended to the animal kingdom, **4, 146**.
- Meteorites**, the "fire ball" of 1803, **3, 168**; Jean Baptiste Biot's investigation of, **3, 169**; scientists differed as to its origin, *ibid.*; Chladni thought that they were one in kind and origin as the "shooting-stars," **3, 170**; the great shower of 1833, **3, 171**; the "miracle" of the falling stone, **3, 172**; invoked by Dr. Mayer to explain the continued heat of the sun, **5, 206**.
- Meteorology, The New Science of**, Chapter V, **3, 168**.
- Methods of living and working** at beginning of nineteenth century compared with those at end, **6, 19-24**.
- Meyer Lothar**, attention drawn to the "law of octaves," **4, 68**.
- Mezzotint**, invented by Van Siegen, **8, 196**.
- Michelangelo**, his famous aphorism that trifles make perfection illustrated by Watt's modification of the steam-engine, **6, 106**.
- Micrometer**, the, Huygens' invention of, **2, 254**.
- Microscope**, invented by Jensen, **2, 77**; in the Newtonian period, **2, 258**; attempts to improve the, **4, 109, 110, 111**; Dr. Amici's reflecting, **4, 112**; Amici's improved compound, **4, 113**; shape of red corpuscles settled by use of the, **4, 114**.
- Milky Way** explained by Galileo, **2, 79**; studied by Herschel, **3, 24**.
- Miller**, in 1788, in association with Symington and Taylor constructed a boat consisting of two hulls, with a paddle-wheel between them worked by a steam-engine, **7, 67**.
- Mineral Depths, The**, Chapter XII, **6, 242**.
- Mining**, early methods of, **6, 242**; prospecting, **6, 243**; geology as an aid to prospecting, **6, 246**; use of the diamond drill in, **6, 247**; problems to be considered in mining, **6, 247**; dangerous gases in mines, **6, 248**; safety lamp invented by Sir Humphry Davy, **249**; methods of illuminating mines, **6, 251**; ventilation of mines, **6, 252**; drainage in, **6, 253**; electric machinery used in, **6, 253**; use of electric drills, **6, 254**; traction in mining, **6, 256**; advantages of electric locomotives in, **6, 259**; electric pumps used in, **6, 263**; use of electricity in coal mining, **6, 266**; coal-cutting machines, **6, 267**; the Lake Superior mines, **6, 272**; "overhead scooping," "caving," and "milling," **6, 273**; "open-pit" mining, **6, 274**;

GENERAL INDEX

- use of steam shovel in, 6, 275.
- "Missing link," the, no longer missing, 5, 173.
- Mitchell, his theory about the Pleiades, 3, 35.
- Mockhoven, Dr. D. von, his experiments in photography, 8, 233.
- Modern Astronomy, The Progress of, Chapter II, 3, 19.
- Modern Chemistry, The Beginnings of, Chapter II, 4, 11.
- Modern Development of Electricity and Magnetism, The, Chapter VII, 3, 229.
- Modern Geology, The Origin and Development of, Chapter IV, 3, 116.
- Modern Sailing Ships, 7, 60.
- Modern Theories of Heat and Light, Chapter VI, 3, 206.
- Mohammed, his liberal view of medicine, 2, 23.
- Mohr, Karl Friedrich, held the doctrine that heat, light, electricity and magnetism cannot be created but only made manifest and transformed one into one another; remembered, therefore, as one of the originators of the doctrine of the conservation of energy, 3, 257.
- Mohs, his scale of the hardness of gems, 9, 301.
- Moissan, Professor, French physicist who first manufactured diamonds in the laboratory, 9, 328.
- Molecules, Lord Kelvin's estimate of the size of those floating in the air, 3, 298; under ordinary circumstances they are in a state of intense but variable vibration, 3, 300; they may be in the form of gas, liquid, or solid, 3, 301; experiments with Crookes's radiometer, *ibid.*; conditions under which they assume a liquid form, 3, 302; and molecular action, 6, 79.
- Mondino of Bologna, "the restorer of anatomy," 2, 37.
- Monier, Joseph, reinforced concrete first used by, 9, 197.
- Monorail Systems, 7, 191.
- Montague Mansion, first home of British Museum, 5, 5; erection of present building, 5, 6.
- Montgolfier, Stephen and Joseph invented and sent up the first balloon, 7, 231.
- Moon, studies of the, 3, 48; speculations concerning, 3, 49; the possible lengthening of the day, 3, 50.
- "Moon's variation," determined by Arabian astronomer, 2, 17; rediscovered by Tycho Brahe, 2, 69.
- Moppert, translation of tablets concerning birth-portents, 1, 73.
- Morgagni, Giovanni Battista, investigations in anatomy, 4, 76.
- Morrison, his translation of Ritter's rendering of part of the poem of Parmenides on the origin of man, 1, 131.
- Morse, Samuel F. B., the father of telegraphy, 8, 17; early experiments of, 8, 19; his first public exhibition of the telegraph, 8, 20; his telegraph used for the first time, 8, 21; his claim to invention contested, 8, 21; principle of the Morse telegraph, 8, 23; experiments with wireless telegraphy, 8, 49; in connection with Draper succeeded in making the first photographic portrait ever taken, 8, 226.
- Morton, Dr. W. T. G., experiments with sulphuric ether resulting in the demonstration of its anæsthetic power, 4, 214.
- Moscicki, Professor, unsuccessful experimenter in commercial extraction of nitrogen from the air, 6, 306.
- Mount Janiculum, the greater

KEY AND INDEX

- number of public Roman mills located near, **6**, 71.
- Moving picture machines, vitascope, vitagraph, biograph, phantoscope, kinematograph, **8**, 251.
- "Mule," the spinning-machine invented by Samuel Crompton, **9**, 32; the self-acting mule, as invented by William Eaton and improved by Richard Roberts, **9**, 35; the modern self-acting mule, **9**, 35.
- Müller, Johannes, studies in embryology, **4**, 122; his dissection of the only available specimen of amphioxus, the lowest of vertebrates, **5**, 125.
- Multiple messages, **8**, 25.
- Munck, localization of motor centres, **4**, 274.
- Mundy, Arthur J., his experiments with submarine signaling, **7**, 85.
- Murdoch, William, his invention of a system of gas lighting, in 1798, **6**, 207; the automobile of, **7**, 158.
- Muscles, **4**, 137; extensor, levers of the first class, **6**, 30; flexor, levers of the third class, **6**, 31. (See also muscular system.)
- Muscular system, the oldest machine in existence, complexity of, governed by laws that apply to other mechanisms, property of contraction, **6**, 43; voluntary and involuntary muscles, **6**, 45-49; nature of muscular action, **6**, 49-52; applications of muscular energy, **6**, 52-54; artificial aids to, **6**, 54 *seq.*; man learns to use muscular system of animals, **6**, 59.
- Museum, The British, Chapter I, **5**, 3.
- Mushet, Robert, his improvement of Bessemer's process of making steel, **6**, 293.
- Musschenbroek, Pieter van, inventor of the Leyden jar, **2**, 280, 282.
- Mutjmaan, Professor W., German experimenter in the commercial extraction of nitrogen from the air, **6**, 306.
- Muybridge, Edward, his interest in the development of chrono-photography, **8**, 250.
- NABONIDUS, ruler of Babylon, his deeds recorded on a cylinder now in the British Museum, **8**, 105.
- Nadar, invented the *Giant*, one of the most remarkable balloons ever constructed, **7**, 253.
- Nansen, Fridtjof, his polar expedition referred to, **7**, 48.
- Napier, cylinder press of, **8**, 124.
- Naples, The Marine Biological Laboratory at, Chapter V, **5**, 113-143.
- Napoleon, contrasted with James Watt as a factor in the progress of civilization, **6**, 18; used a system of telegraphic signals during his Russian campaign, **8**, 3.
- Natural History to the Time of Linnæus, Chapter XV, **2**, 297.
- Natural Knowledge, The Royal Society of London for Improving, Chapter II, **5**, 14.
- Natural versus supernatural, **5**, 233.
- Nautical Almanac, The, **7**, 37.
- Nautilus*, the, first submarine boat built by Fulton, **7**, 99.
- Navigating the Air (see also Aeroplane), Chapter IX, **7**, 226; Leonardo's sketches of flying-machines, **7**, 227; the flying-machine of Besnier, **7**, 228; the flight of the Marquis de Bacqueville, **7**, 229; Cavendish's discovery of hydrogen gas and its effect upon aeronautics, **7**, 230; the experiments of Dr. Black and Dr. Priestly, **7**, 230; the toy balloons of Cavallo, **7**, 230;

GENERAL INDEX

- the balloon invented by the Montgolfier brothers, **7**, 231; the first successful balloon ascension, **7**, 232; Rozier, the first man to make an ascent in a balloon, **7**, 235; Blanchard's attempt to produce a dirigible balloon, **7**, 238; hot-air balloons and hydrogen-gas balloons, **7**, 240; Rozier, the first victim of ballooning, **7**, 241; progress in mechanical flight, **7**, 244; Giffard "the Fulton of Aerial Navigation," **7**, 251; the voyages of the *Giant*, constructed by Nadar, **7**, 252; early war balloons and dirigible balloons, **7**, 257; the use of balloons during the Franco-Prussian War, **7**, 258; the dirigible balloon achieved, **7**, 262; the dirigible balloon of Dupuy de Lome, **7**, 263; the aluminum balloon of Herr Schwartz, **7**, 264; the dirigible balloons of Count Zeppelin, **7**, 265; the balloons of Santos-Dumont, **7**, 267.
- Navigation, limits of ancient, **6**, 13.
- Neanderthal skull, regarded by modern zoologists as a distinct species of man, **3**, 102.
- Neilson, of Glasgow, inventor of the flat gas burner, **6**, 208.
- Neolithic civilization supplanted by the invasion of cultivated people from the East, **1**, 31.
- Neon, discovery of, **5**, 87.
- Neptune, the planet, its existence predicted by the German astronomer Bessel, **3**, 42; discovered five years later by John Couch Adams, of England, *ibid.*
- Neptunists, a name given to the followers of Werner, who denied the theory of the metamorphosis of rocks, **3**, 131.
- Nerve cells, process of staining, **4**, 282; each an isolated entity, **4**, 283; importance of the discovery of, **4**, 285.
- Nerves, function of, **4**, 249.
- Newcomb, Simon, used fifty thousand separate and distinct observations in preparing his tables of the sun, **7**, 39.
- Newcomen, Thomas, atmospheric engine of, described, **6**, 89; similarity to Papin engine, **6**, 89; injection of cold water for condensation, automatic working of valve, **6**, 91; rapid adoption, **6**, 92.
- New Cosmology—Copernicus to Kepler and Galileo, The, Chapter IV, **2**, 52.
- New Institutions of Learning, Philosopher Scientists and, Chapter IX, **2**, 191.
- Newlands, John A. R., studies of atomic weights, **4**, 67.
- New Physics, Galileo and the, Chapter V, **2**, 93.
- New Science of Paleontology, The, Chapter III, **3**, 74.
- New Science of Meteorology, The, Chapter V, **3**, 168.
- New Science of Experimental Psychology, The, Chapter IX, **4**, 245.
- New Science of Oriental Archaeology, The, Chapter X, **4**, 287.
- Newton and the Composition of Light, Chapter XI, **2**, 225.
- Newton and the Law of Gravitation, Chapter XII, **2**, 236.
- Newton, Instruments of Precision in the Age of, Chapter XIII, **2**, 252.
- Newton, The Successors of, in Astronomy, Chapter I, **3**, 3.
- Newton, Isaac, **2**, 225-251; discovery of the composition of white light, **2**, 227; the nature of color, **2**, 233; the law of gravitation, **2**, 236; further computations in the *Principia*, **2**, 243-250; invention of reflecting telescope, **2**, 255; supported the theory which regarded light as a corpuscular emanation, **6**, 153; sug-

KEY AND INDEX

- gested a means of measuring the altitude of astronomical bodies, **7**, 20.
- Newton, Sereno, sent to England to study the workings of cylinder presses, **8**, 124.
- New York*, the, one of the first twin-screw boats to make ocean records, **7**, 81.
- New Zoology, Ernst Haeckel and the, Chapter VI, **5**, 144.
- Niagara in Harness, Chapter X, **6**, 183.
- Niagara, Falls of, number of tons of water falling each hour, **6**, 184; electric power-house at, **6**, 186; effect upon, by the electric power-houses, **6**, 192; transmission of electrical power from, **6**, 194; soda manufactories at, **6**, 300.
- Niagara*, detailed by the United States Government to lay the first Atlantic cable, **8**, 34.
- Nicéphore de Niepce, discovered a method of making permanent photographs by a crude and complicated process, **8**, 222; his pictures regarded as the first photographic pictures ever made, **8**, 222.
- Nicetas, taught that the world is in motion, **1**, 216.
- Nicholson, William (with Carlisle), discovered that a galvanic current would decompose chemicals in solution, **3**, 233; **8**, 11; decomposed water into its elements hydrogen and oxygen, **3**, 233.
- Nicholson, William, cylinder press invented by, **8**, 123.
- Nile, floods of, without which civilization would be impossible in Egypt, **1**, 35.
- Nineteenth-Century Medicine, Chapter VIII, **4**, 199.
- Nineteenth century, conditions of existence and methods at beginning compared with those at end, **6**, 19-24.
- Nippur, expedition to, **1**, 59.
- Nitrate Beds, of Chili, **6**, 305.
- Nitrogen, discovered by Cavendish, **5**, 87; method of obtaining it from the air, **6**, 303; as a plant food, **6**, 304; Professor Birkeland's discovery of a method of obtaining it, **6**, 306; method discovered by Professors Kowalski and Moscicki, at Freiburg, **6**, 306; commercial plant for obtaining it at Notodden, Norway, **6**, 309; Frank and Caro process of nitrogen fixation, **6**, 309.
- Noble, Sir Andrew, experiments with cordite in obtaining high temperatures, **6**, 315.
- Norman, Robert, "dipping" of the magnetized needle first observed by, **7**, 13; attempted to overcome the dip of the magnetic needle by applying a balancing apparatus, **7**, 14.
- Northrop, inventor of the perfected power-loom, **9**, 51.
- Notodden, Norway, commercial nitrogen plant located at, **6**, 309.
- Novelty*, locomotive, description of the, **7**, 132.
- Nuclei of plant cells, discovered by Robert Brown, **4**, 115; Dr. Schleiden brings to popular attention, **4**, 118.
- Oceanic*, the first ocean greyhound, **7**, 80.
- Oersted, Hans Christian, his experiments to show the effect of an electric current upon a suspended magnetic needle, **3**, 236; it showed the close relationship between magnetism and electricity, **3**, 238; **6**, 176; effects of his important discovery, **3**, 239.
- Oken, Lorenz, extends the doctrine of metamorphosis to the animal kingdom, **4**, 146; his theory of spontaneous generation and evolution of species, **4**, 160.
- Oil Engines, Gas and, **6**, 132.
- Olbers, Dr., discoverer of the

GENERAL INDEX

- planet Pallas, **3**, 40; his explosion theory, **3**, 41; his opinion of the great comet of 1680, **3**, 52.
- Oldfield, Barney, his record at Ormonde, the fastest mile ever made by an automobile, **7**, 166.
- Olympic*, passenger steamer of the White-Star Company, **7**, 90.
- Olzewski's experiment with liquid oxygen, **5**, 61.
- Opdyke, George, pioneer in the wholesale manufacture of clothing, **9**, 78.
- Organic Evolution, Theories of, Chapter VI, **4**, 140.
- Organic matter, possibilities of producing, out of inorganic, **5**, 224.
- Organicists, system of, **4**, 185; theory of, **4**, 187.
- Organism, animal, comprehensive view of, **4**, 137; economy of the, **4**, 138.
- Oriental Archæology, The New Science of, Chapter X, **4**, 287-302.
- Oriental ecclesiasticism as a cause of indifference to science in the dark age, **2**, 4.
- Origin and Development of Modern Geology, Chapter III, **3**, 116.
- Otis, Elisha G., introduced the passenger elevator, **9**, 164.
- Otto, Dr. N. A. (with E. Langen), made important improvement in piston arrangement of gas engine, **6**, 136; improves gas engine by compressing the explosive mixture in the working cylinder before igniting it, **6**, 138; the gasoline engine perfected by, **7**, 157.
- Otto cycle, as exemplified in gas engines, **6**, 136, and **6**, 138.
- Owen, Richard, discovers the *Trichina spiralis*, **4**, 207.
- Ox, domestication of, **6**, 59.
- Oxygen, liquefied by Pictet and Cailletet, **5**, 42; Olzewski's experiments in, **5**, 61.
- PAGE, C. C., his efforts to produce a storage-battery car, **7**, 180.
- Paget, James, his discovery of the *Trichina spiralis*, **4**, 207.
- Painless dentistry, experiment of Dr. Horace Wells in 1844, **4**, 213.
- Paints, Dyes, and Varnishes, Chapter XI, **8**, 258.
- Paints, different from dyes and varnishes, **8**, 258; principle of the process of levigation, **8**, 259; the importance of water and the drying-oils, **8**, 261; linseed-oil the most important to the painter, **8**, 262; turpentine most useful for certain purposes, **8**, 264; methyl and ethyl alcohol used extensively, **8**, 264; the pigments of antiquity, **8**, 265; black pigments, **8**, 267; *seq.*; white pigments, **8**, 274 *seq.*; some "chrome" pigments, **8**, 281; other yellow mineral pigments, **8**, 285; some brilliant but poisonous pigments, **8**, 288; green mineral pigments, **8**, 292; blue pigments from the mineral world, **8**, 295; the brown mineral pigments, **8**, 302; pigments from vegetable and animal sources, **8**, 303; the coal-tar colors, **8**, 311.
- Paleontology, The New Science of, Chapter III, **3**, 74-115.
- Pancreas, the, discovery that it plays a part in the process of digestion, **4**, 129; all-important in the digestion of starchy and fatty foods, **4**, 130.
- Panhard, M. (with M. Levassor), invents a modern gasoline motor, **6**, 140; applied the Daimler motor to four-wheeled vehicles and thus developed the automobile, **7**, 157.

KEY AND INDEX

- Paper, the manufacture of, 8, 159; materials for making, 8, 161; making paper by hand, 8, 162; "watermark," "wove," and "laid" paper, 8, 163; modern rag-paper, 8, 164; paper from wood-pulp, 8, 171; paper car-wheels, 8, 180; papier-maché, 8, 182.
- Papin, Denis, conceived idea of transmitting power by means of a piston, 6, 88; produced vacuum in cylinder by cooling, 6, 88.
- Pappenheim, discovered that the pancreas shares in digestion, 4, 129.
- Paracelsus to Harvey, From, Chapter VII, 2, 156.
- Paracelsus, life, 2, 156; "four pillars" of his medical teachings, 2, 159; doctrine of "signatures," 2, 160; use of magnets, 2, 161; condemnation of surgery, 2, 162; his influence, 2, 162.
- Parasitic diseases, discovery of, 4, 204; importance of this discovery upon the science of medicine, 4, 206.
- Paré, Ambroise, "the father of French surgery," 2, 181; his innovations in the field of surgery, 2, 182.
- Parisian system of sewage disposal, the, 5, 200.
- Parmenides, a distinguished ornament of the Eleatic School, 1, 114; his theories concerning the earth, 1, 130; his cosmogonic speculations, 1, 131.
- Parsons, C. A., inventor of steam turbine, 1884, 6, 124; description of turbine, 6, 125; effect of his invention upon navigation, and the generation of power, 6, 127.
- Pascal, his barometrical experiment, 2, 122.
- Pasteur Institute, the, 5, 178-186; the tomb of Pasteur within the walls, 5, 181; aims and objects of, 5, 182; anti-rabic treatment given at, 5, 183; a school of bacteriology, 5, 184; the regular staff of, 5, 185; sheep and cattle treated at, *ibid.*
- Pasteur, Louis, architectural design of a molecule illustrated by, 4, 63; refutation of the doctrine of spontaneous generation, 4, 180; corroborated by Tyndall, *ibid.*; and the germ theory of disease, 4, 217; studies in fermentation, 4, 218; cause of the decay of organic tissues, 4, 220; experiments with grape sugar, 4, 221; settles question of bacilli as cause of anthrax, 4, 228; experiments with chicken cholera, 4, 232; and the microbe of anthrax, 4, 233; demonstrates the protection afforded animals by inoculation, 4, 238, 239; his inoculations to prevent hydrophobia, 4, 240; his tomb, 5, 181.
- Paul of Aegina, Byzantine surgeon, 2, 32.
- Paul, Lewis, his claim to the invention of the first spinning-machine, 9, 22 and 27.
- Paulhan, Louis, his spectacular flight from London to Manchester, 7, 296.
- Payen, his discovery of the composition of the cell walls of vegetables, 4, 124.
- Peary, Robert E., discoverer of the North Pole, 7, 49.
- Peel, Robert, British Statesman, employed James Hargreaves to construct a carding-machine, 9, 16.
- Peligot, M., describes the method of making window-glass, 9, 289.
- Penstock, at the Niagara Falls electrical power-plant, 6, 188.
- Pepsin, an active principle in gastric juice, 4, 129; detected by Spratt and Boyd, *ibid.*
- Percussion, Piorry's method of mediate, 4, 203.

GENERAL INDEX

- Periscope, its use on submarines, **7**, 111.
- Perkin, produced the first aniline color, **8**, 312.
- Perraudin, first accounted for the presence of bowlders on the mountain-tops, **3**, 145; his idea laughed at by all except Charpentier, **3**, 146.
- Perrin, J., his theories of radio-activity, **5**, 106.
- Perseverance*, locomotive, **7**, 133.
- Peter of Abano, physician, **2**, 36.
- Petrie, Prof. W. M. Flinders, importance of his work as an Egyptologist, **1**, 28.
- Pett, Phineas, ships produced by, **7**, 60.
- Philippe, Louis, King of France, received first message through cable under the English Channel in 1845, **8**, 32.
- Philopater, Ptolemy, description of ship said to be used by, **7**, 57.
- Philosopher-Scientists and New Institutions of Learning, Chapter IX, **2**, 191.
- Philosophers in Italy, The Early Greek, Chapter VI, **1**, 112.
- Philosopher's stone, **2**, 124, 131.
- Phlogiston Theory in Chemistry, The, Chapter I, **4**, 3.
- Phlogiston theory, the, in chemistry, **4**, 3-10; influence of Boyle's teaching of, **4**, 5; Stahl's theory of, **4**, 6; peculiarities of, **4**, 7; many complications and final overthrow of, **4**, 9.
- Phonautograph, invented by Mr. Leo Scott, **8**, 93.
- Phonograph, the, invented by Thomas A. Edison, **8**, 93; description of, **8**, 97.
- Photography, the importance of the discovery of, in spectroscopy, **4**, 70; discovered by Daguerre, **8**, 202; the part played by it in the discovery of radio-activity by Becquerel, **8**, 220; Daguerre discovered a practical method of developing photographic plates, **8**, 220; Scheele's experiments, **8**, 220; Rumford's arguments, **8**, 221; first practical application by Thomas Wedgewood, **8**, 221; Sir Humphry Davy's experiments with the camera obscura, **8**, 221; Nicéphore de Niepce discovered a method of making permanent photographs, **8**, 222; the daguerreotype, **8**, 224; the first portraits ever taken, **8**, 226; Talbot's "calotype" process, **8**, 227; discovery of the "gallo-nitrate" process by J. B. Reade, **8**, 228; Goddard made the discovery that bromine vapor rendered plates more sensitive, **8**, 228; process of toning or gilding invented by Fizeau, **8**, 228; glass negatives, invented by Niepce St. Victor, and improved by Blanquart and Le Gray, **8**, 229; the Archer collodion plate, **8**, 230; "collodion-emulsion" process invented by Bolton and Sayce, **8**, 231; discovery of Cary Lea and W. Cooper, **8**, 232; Wortley's discovery, **8**, 232; Researches with chloride and bromide of silver, by M. J. S. Stas, **8**, 232; the discovery of Mockhoven, **8**, 233; the flexible film, **8**, 233; photographing in natural colors, **8**, 234; Becquerel the first to take up specifically the matter of color-photography, **8**, 235; standing light waves, **8**, 236; Zenker's theory, **8**, 236; Lipmann's direct method of color-photography, **8**, 237; Clerk-Maxwell's experiments, **8**, 237; invention of the slide-carrier by F. E. Ives, **8**, 238; single-lens camera invented by Sanger-Shepard, **8**, 238; three-lens camera devised by Chéron, **8**, 240; method of Ducos du Hauron, **8**, 241;

KEY AND INDEX

- first screen-plate process put forward by Dr. Robert Joly, **8**, 242; practical screen-plate produced by J. W. McDonough, **8**, 242; the invention of Robert Krayne, **8**, 242; color-screen invented by Powrie, **8**, 243; "Random grain" plates invented by Messrs. Lumière, **8**, 243; the Lumière "autochrome" plate, **8**, 243; the "omnicolor" plate, **8**, 244; the method of Szczepanik, **8**, 245; Lipmann's method of employing the minute spectra of prisms, **8**, 246; improved method of Chéron, **8**, 248; the future of color-photography as outlined by Doctor Mees, **8**, 247; method of Chapman Jones, **8**, 247; Chrono-photography—moving pictures, **8**, 248; phenakistoscope invented by Plateau, **8**, 249; zoetrope or "wheel of life," **8**, 249; Raynaud's praxinoscope, **8**, 249; Muybridge, Marey, and Anschütz took first steps in the development of chrono-photography, **8**, 250; the zoo-praxiscopes devised by Muybridge, **8**, 250; photographic gun invented by Jansen, **8**, 250; the photoscope, **8**, 250; Edison's kinoscope, **8**, 251; method of making moving pictures, **8**, 251; the slot machine or mutoscope, **8**, 254; the uses of photography, **8**, 255; the kinematograph, **8**, 256; mystery of the background of the eye solved by stereophotography, **8**, 256; microphotography indispensable to the pathologist, **8**, 256; the use of the camera in zoology and botany, **8**, 256; practical use of the kinematograph by the zoologist, **8**, 256; the camera replacing the plane-table, **8**, 257. Photogravure, process of, **8**, 217. Phrenology, studies in, by Gall, **4**, 247.
- Physical diagnosis, Corvisart lays the foundation of, **4**, 199.
- Physical Laboratories and Physical Problems, Some, Chapter IV, **5**, 73.
- Physical Science, The Successors of Galileo in, Chapter X, **2**, 204.
- Physicians, in the early Roman days, **1**, 273; special laws enacted to protect, **1**, 275; exempted from taxes and military service, **1**, 276.
- Physics, Galileo and the New, Chapter V, **2**, 93.
- Physiology, Anatomy and, in the Eighteenth Century, Chapter IV, **4**, 73.
- Physiology, Anatomy and, in the Nineteenth Century, Chapter V, **4**, 102-139.
- Piazzi, an Italian astronomer who discovered the planet Ceres, **3**, 40.
- Picard, James, patents crank and connecting-rod for use on the steam-engine, **6**, 100.
- Picnotti, his invention of the ring armature, **6**, 179.
- Pigments, of antiquity, **8**, 265; black pigments, **8**, 267; white pigments, **8**, 274; some "chrome" pigments, **8**, 281; other yellow mineral pigments, **8**, 285; some brilliant but poisonous pigments, **8**, 288; green mineral pigments, **8**, 292; blue pigments from the mineral world, **8**, 295; the brown mineral pigments, **8**, 302; pigments from vegetable and animal sources, **8**, 303.
- Pinel, Dr. Philippe, leader in reforms for the care of insane, **4**, 245; liberation of the inmates at the Bicêtre and the Salpêtrière, **4**, 246.
- Piorry's method of mediate percussion, **4**, 203.
- Piston engine as means of transmission of power, idea originated with Papin, **6**, 88.

GENERAL INDEX

- Pitch-blende, a radio-active substance, 5, 98.
- Pithecanthropus erectus*, the fossil of the ape-man found by Dr. Dubois in the island of Java, 3, 113.
- Pitt, William, his interest in Fulton's submarine boats, 7, 100.
- Pizarro, found cotton growing indigenously in Mexico and Peru, 9, 7.
- Plagues, their influence on mediæval medical science, 2, 33, 41.
- Planché, Gaston, his invention of the electric storage battery, 3, 246.
- Planet*, the, constructed by Stephenson, 7, 135.
- Plateau, M., invented a moving-picture machine called the phenakistoscope, 8, 249.
- Plato, Aristotle, and Theophrastus, Chapter VIII, 1, 178.
- Plato, his visit to Egypt to study the mysteries of its fabled learning, 1, 56, 84; the greatest thinker and writer of his time, 1, 180; a mystical dreamer and sociologist, 1, 182; considered manual toil degrading, 6, 26.
- Platt, Messrs. Fielding and, their rotary engine, 6, 122.
- Plinius Secundus, the most famous Latin writer of antiquity, 1, 265; soldier and investigator, 1, 266.
- Pliny, his unbounded respect for Oriental learning, 1, 56.
- Plutarch, his narrative of the experiments of Archimedes, 6, 34.
- Plutonists, a name given to the followers of Hutton, 3, 131.
- Poker, lever of the first class, 6, 30.
- Pole, the quest of the, 7, 47; Henry Hudson's farthest north record, 7, 48; discovery of, 7, 49; controversy over the discovery of the pole, 7, 49; method of determining arrival at the pole, 7, 50.
- Polo, Marco, mistakenly accredited with bringing the compass from the East, 7, 46.
- Polonium, discovery of the radio-active properties of, 5, 101.
- Ponderable Matter, The Ether and, Chapter IX, 3, 283.
- Popoff, Prof. A., apparatus used by, for sending wireless messages, 8, 54.
- Porta, Giovanni Battista della, early in the seventeenth century published idea of utilizing steam for raising water, 6, 83.
- Posidonius, reference to his measurement of the size of the world, 7, 5.
- Post-Socratic Science at Athens—Plato, Aristotle, and Theophrastus, Chapter VIII, 1, 178.
- Potter, Humphrey, cock boy, invention of beam connection for operating engine valves attributed to, 6, 91; reasons for doubt, 6, 92.
- Pottery and Pottery Making. See Products of Clay and Fire.
- Pouchet, M. F. A., belief in spontaneous generation, 4, 180.
- Power, transmission of, by means of gears, belts, chains, 6, 35-36.
- Powrie, John W., color-screen method adopted by, 8, 243.
- Predynastic period of Egyptian history, the, 1, 28.
- Preece, Sir William H., experiments of, 8, 50.
- Prehistoric man, the, 1, 29.
- Prehistoric Science, Chapter I, 1, 3.
- Prehistoric science, not a contradiction of terms, 1, 3; the distinctive prehistoric and historic epochs, 1, 26, 27.
- Prestwich, his conclusions in regard to the flint instruments

KEY AND INDEX

- in the collection of M. de Perthes, **3**, 101.
- Priestley, Joseph, important discoveries of, **4**, 18; flight from French mob, **4**, 19; oxygen his greatest discovery, **4**, 20; refusal to reject the phlogiston theory, **4**, 36; experiments in the mysteries of respiration, **4**, 93; his experiments with balloons, **7**, 230.
- Primitive books, **8**, 99; five primitive types, **8**, 99; the papyrus roll of the Egyptian, **8**, 100; the tablet of baked clay, **8**, 103; prism or cylinder of clay used by the Babylonians and Assyrians, **8**, 105; the palm-leaf books of the Hindus, **8**, 106; folded books, **8**, 108; the text of ancient books, **8**, 112.
- Primitive man, our knowledge of, **1**, 6; he observed that the sun gives heat and light and the moon and stars light only, **1**, 7; noted the changing phases of the seasons, *ibid.*; noted that the sun, moon, and stars move across the heavens, **1**, 8; had some idea of the law of universal terrestrial gravitation, **1**, 9; knew the facts concerning the rigidity of solids and the mobility of liquids, **1**, 10; knew that friction produced heat and fire, **1**, 11; practised instinctive therapeutics, **1**, 13; idea of death, **1**, 15; had vague conceptions of an endless life, **1**, 18; ideas of psychology, mathematics, and political economy, **1**, 19; knew what was essential to communal harmony, **1**, 21; his basal principles are the foundations of modern science, **1**, 22; had "innate" ideas of a future life, **1**, 23; owes a debt of gratitude to his barbaric predecessor, **1**, 24.
- Prince Rupert, erroneously ac- credited with invention of the mezzotint, **8**, 196.
- Printing and Making of Modern Books, The, Chapter VII, **8**, 119-158.
- Printing, Chinese credited with the discovery of the art of, **8**, 119; the first book printed from movable types, **8**, 120; the father of printing, **8**, 120; the first printing-press ever invented, **8**, 120; improvement made by William Blaew, **8**, 122; press produced by the Earl of Stanhope, **8**, 122; press invented by Isaac Adams, **8**, 122; the cylinder press invented by William Nicholson, **8**, 123; practical solution of "cylinder press" credited to Friedrich Koenig, **8**, 123; Napier's cylinder press equipped with grippers or "fingers," **8**, 124; the American printing-press without a rival, **8**, 124; the "stop cylinder" invented by Dutartre, **8**, 125; the advent of the type-revolving machine, **8**, 127; the press invented by Richard M. Hoe, **8**, 127; ingenious device patented by Stephen D. Tucker, **8**, 130; a modern newspaper press, **8**, 131; a perfected magazine press, **8**, 135; the "Rotary Art" press for color printing, **8**, 137; other aids to the printer, **8**, 139; the Mergenthaler linotype, **8**, 142; Lanston monotype machine, **8**, 145; the graphotype invented by J. H. Goodson, **8**, 149; type-setting machines, **8**, 150; the Dow type-setting machine, **8**, 151; the development of book-binding, **8**, 153.
- Printing-press (see also Printing), its part in the development of medical learning, **2**, 39.
- Problems, Some Unsolved Scientific, Chapter VIII, **5**, 203.

GENERAL INDEX

- Problems, some unsolved scientific, **5**, 203-229; solar and telluric, **5**, 205-213; physical, **5**, 213-220; life, **5**, 220-229; of anthropology, **5**, 228.
- Problems, Medical, Some Medical Laboratories and, Chapter VII, **5**, 178.
- Problems, Physical, Some Physical Laboratories and, Chapter IV, **5**, 73.
- Products of Clay and Fire, Chapter X, **9**, 227-271.
- Products of Clay and Fire, Chapter X, **9**, 227; pottery-making by primitive man, **9**, 227; the manufacture of pottery, **9**, 227; the raw materials, **9**, 232; mixing the materials, **9**, 238; the glaze and its preparation, **9**, 243; methods of making pottery by hand, **9**, 246; machines that make pottery, **9**, 255; from clay to china, **9**, 260; decorating the ware, **9**, 271.
- Progress in Electricity from Gilbert and Von Guericke to Franklin, Chapter XIV, **2**, 259.
- Progress of Modern Astronomy, The, Chapter II, **3**, 19.
- Progress, the only real progress due to the development of mechanical inventions, **6**, 12-17.
- Property, the foundation-stone of civilization, **6**, 25.
- Prospect, Retrospect and, Chapter IX, **5**, 230.
- Protoplasm, studies in, by De Bary and Schultze, **4**, 125.
- Proust, Louis Joseph, disputes Dalton's atomic theory, **4**, 41.
- Prout, Dr. William, studies of atomic weights, **4**, 66; his alleged law revived by Dumas, **4**, 67; detected hydrochloric acid in gastric juice, **4**, 129.
- Pseudo-Sciences, Two—Alchemy and Astrology, Chapter VI, **2**, 124.
- Psychology, The New Science of Experimental, Chapter IX, **4**, 245.
- Ptolemy, erected a museum and collected a library which made Alexandria the culture-centre of the world, **1**, 190; the last great astronomer of antiquity, **1**, 267; discovered the moon's evection, **1**, 268; his writings became the sole astronomical text-book of the Middle Ages, **1**, 269; his theory of epicycles, **1**, 270; the errors in the colored maps attributed to him may have influenced Columbus on his voyages of discovery, **1**, 271.
- Pulley, principle of, **6**, 33; perfected by Archimedes, **6**, 34.
- Pump, electric, use in mining, **6**, 263.
- Pumps and pumping (see also Suction, Ctesibius), della Porta states idea of utilizing steam for raising water; idea put into effect by Caus, **6**, 83; expansive force of steam first applied by Marquis of Worcester, **6**, 84; Savery's steam pump, **6**, 85; Newcomen's pumping engines, **6**, 89.
- Purkinje discovers that the pancreas shares in digestion, **4**, 129.
- Pyramids, the building of, **1**, 32; oriented in strict accordance with some astronomical principle, **1**, 33.
- Pyramids of Egypt, building of, described by Diodorus Siculus, **6**, 37.
- Pythagoras, a youthful athlete, **1**, 112; one of the fathers of Grecian thought, **1**, 114; the founder of an independent school of philosophy, **1**, 116; advocates the theory of the sphericity of the earth, **1**, 118, 119; the discoverer of the identity of Hesperus and Lucifer, **1**, 120; carried the science of geometry to perfection, *ibid.*; no written line of his has come to us, **1**, 121; a

KEY AND INDEX

- summary of his doctrines as quoted by Diogenes, **1**, 122; an agnostic as regards the current Greek religion, **1**, 127.
- QUADRANT, the instrument devised by Hadley for measuring the altitude of astronomical bodies, **7**, 20.
- Question as to living forms on other worlds, **5**, 220.
- Quinine, its introduction, **2**, 185.
- Quinquet, an oil lamp invented by him, **6**, 205.
- RABIES, or hydrophobia, slow in development, **5**, 182; its treatment by inoculation at the Pasteur Institute, **5**, 183.
- Rackenzaun, Anthony, his work on storage-battery systems, **7**, 189.
- Radio-active bodies, nature of emanations from, **5**, 102; different kinds of rays produced by, **5**, 103; source of energy of, **5**, 106; suggestion that this energy may some day be utilized in the propulsion of mechanisms, **6**, 318.
- "Radio-activity," **5**, 97-102; so termed by Madame Curie, **5**, 101; source of energy of, **5**, 106; and the structure of the atom, **5**, 107; discovered by Becquerel, **8**, 220.
- Radiolarians, the discovery of numerous species by Ernst Haeckel, **5**, 154; part played in evolution, **5**, 155.
- Radium, discovered by Pierre Curie and his wife, **5**, 100; power of, in penetrating substances, **5**, 101, 102; an elementary substance, **5**, 104; Ramsay's experiments with, *ibid.*; presence of helium in, **5**, 105; methods devised for testing heat given off by, **5**, 110; its heat-giving qualities, **5**, 211; amount of energy stored in, **6**, 318.
- Ramillies, attacks on, by submarines, **7**, 102.
- Ramony Cajal, Dr. S., demonstration of independent nerve filaments, **4**, 283; importance of discovery, **4**, 285.
- Ramsay, Sir William, and new gases, **5**, 82-92; laboratory and equipment of, **5**, 83; characterizes the importance of industrial chemistry, **6**, 299.
- Rankine, William John Macquorn, had a part in perfecting theory of steam engine, **6**, 115.
- Raphael, took active interest in copper engraving, **8**, 194.
- Rawlinson, Canon, his estimate of Babylonian influence, **1**, 82; contrasted with that of Diodorus, **1**, 83.
- Rawlinson, Sir Henry, "father of Assyriology," **4**, 229; **5**, 9; helped to decipher the Assyrian hieroglyphics, **8**, 228.
- Rayleigh, Lord of the Royal Institution, experiments with gases, **5**, 85; his laboratory experiments with the fixation of nitrogen, **6**, 306.
- Raynaud, invented a moving-picture machine called the praxinoscope, **8**, 249.
- Reade, Rev. J. B., discoverer of a "gallo-nitrate process," **8**, 228.
- Re, Filipo, his theories of radio-activity, **5**, 106.
- Réaumur, René, the stomach as a grinding or triturating organ, settled by, **4**, 88; his experiments with gastric juice, **4**, 89.
- Red corpuscles of the human blood, shape of, settled by Joseph Jackson Lister, **4**, 114; functions of, **4**, 135.
- Refrigerator machines, use of liquefied gases in, **5**, 61-63.
- Rembrandt, the famous painter also a master etcher, **8**, 196.
- Renard and Krebs, constructed *La France*, a motor-driven balloon, **7**, 264.
- Renucci, F., and the itch mite, **4**, 206.

GENERAL INDEX

- Republic*, rescue of passengers and crew due to submarine signaling apparatus, 7, 88.
- Respiration, the function of, 4, 92; experiments in the mysteries of, 4, 93, 94; Erasmus Darwin and vegetable, 4, 94.
- Restoration of Assyrian sculpture, 4, 293.
- Retgers, Dutch mineralogist discovers a colorless compound of silver and thallium used in testing the specific gravity of gems, 9, 303.
- Retrospect and Prospect, Chapter IX, 5, 230.
- Retrospect and prospect, 5, 230-242; scientific attitude of mind, 5, 230-232; natural versus supernatural, 5, 233, 234; inductive versus deductive reasoning, 5, 235-238; logical induction versus hasty generalization, 5, 239-242.
- Retrospective Glance at Classical Science, A, Chapter XI, 1, 285.
- Retrospective glance, the span from Thales to Galen compassed about eight hundred years, 1, 286; the true hypothesis concerning the sun and the planetary system, 1, 287; the beginnings of great things in the sciences, 1, 288; the homes of the great scientists were scattered over a wide territory, 1, 289; Plato the only great scientist who was born in Greece, *ibid.*; racial mingling, 1, 290; early development of thought and Oriental science, 1, 291; the entire school of Alexandrians free from superstition, 1, 292; the attitude of the Roman mind towards science, *ibid.*; beliefs based upon pseudo-scientific inductions, 1, 294; miracle workers, 1, 295; "The Thundering Legion," 1, 296; Xiphilinus's account of the battle between the Romans and the hostile Quadi, 1, 297.
- Rey, Jean, experiments with air, 4, 6.
- Rhazes, Arabian physician, 2, 24.
- Ricard, Bishop, with Dr. Atherstone made the first tests of South African diamonds, 9, 316.
- "Riddle of the Sphinx," how read, 4, 287.
- Rittenhouse and Hopkins, invented and sent up a balloon, 7, 237.
- Roberts, Richard, improves the self-acting mule, 9, 35.
- Robinet and the idea of the transmutation of species, 4, 149.
- Rocket*, description of the, Stephenson's famous locomotive, 7, 133.
- Rocks, the origin of stratified, 3, 143; the "transition" and "secondary" systems, 3, 156; the Silurian and Devonian systems, 3, 157; the Laurentian system, *ibid.*; the formation of the Adirondack and Storm King range are patriarchs of the kind, 3, 158; different in character, 3, 159; the backbone of the future continent, 3, 161; the strata of the Paleozoic period, 3, 162; the Rocky range, 3, 163.
- Roderick and Joseph, and Martin de Bohemia, credited with inventing the apparatus known as the astrolabe, 7, 19.
- Roentgen, Professor Wilhelm Conrad, the discoverer of the "X-ray," 3, 248; its extraordinary results on the photographic film, *ibid.*; the apparatus for producing the rays, 3, 251; the composition of the rays not fully determined, 3, 252.
- Rolando's method of cutting pieces of brain tissue for microscopical examination, 4, 277.

KEY AND INDEX

- Rolls, Charles R., his remarkable flight across the English Channel, **7**, 294.
- Roman Period, Science of the, Chapter X, **1**, 253.
- Roofs, different types of, **9**, 153.
- Rosel, Prof., of the University of Bern, has demonstrated the presence of microscopic diamonds in steel, **9**, 329.
- Rosellini extended the knowledge of the phonetic value of inscriptions on the Rosetta Stone, **1**, 27.
- Rosetta Stone, its hieroglyphics deciphered by Dr. Thomas Young, **1**, 27; the, **4**, 287; biography of, **4**, 288; decipherment of, **4**, 289, 290; in British Museum, **5**, 8.
- Rosicrucians, **2**, 136.
- Ross, Sir James, located the northern magnetic pole, **7**, 13.
- Ross, Louis, his automobile record at Ormonde, **7**, 165.
- Rotary engine, principle of, **6**, 119; James Watt's invention of, **6**, 119; Joshua Routledge's, **6**, 120; of Rev. Patrick Bell, **6**, 121; of Lord Armstrong, **6**, 120; of Messrs. Fielding and Platt, **6**, 122; of Mr. Hoffman of Buffalo, **6**, 123; estimated speed of locomotive using Hoffman engine, **6**, 123; see also "Steam-Engine."
- Routledge, Joshua, design of his rotary engine described, **6**, 120.
- Rotary motion, in steam-engine, first attempts at, by Watt, **6**, 99-100; crank and connecting rod patented by Picard, **6**, 100; Watt invents sun-and-planet gearing, **6**, 100; possibilities of, not realized at first, **6**, 100-110.
- Rowboat, the oar a modified form of lever, **6**, 58; ancient ships chiefly propelled by oars, **7**, 57.
- Roux, Dr., his paper on anti-toxine, **4**, 242.
- Royal Academy of Sciences, at Paris, **2**, 202; at Berlin, *ibid.*
- Royal Institute, founded 1801, **4**, 46; Humphry Davy assumed chair of chemical philosophy of, **4**, 46.
- Royal Institution and the Low-Temperature Researches, The, Chapter III, **5**, 29.
- Royal Institution of Great Britain, foundation and founder, **5**, 29, 30; methods and results at, **5**, 33-38.
- Royal Society of London for Improving Natural Knowledge, The, Chapter II, **5**, 14.
- Royal Society of London, the, its origin, **2**, 201; **5**, 14-28; visitors to, **5**, 15; the lecture-room of, **5**, 17; comparison between, and the Royal Academy of Science of Berlin, **5**, 18; library and reading-rooms of, **5**, 19; busts of distinguished members of, **5**, 20; priceless relics in, **5**, 21, 22.
- Royal Swedish Academy, **2**, 202.
- Rozier, Pilatre de, the first man to make an ascent in a balloon, **7**, 235; the first victim of ballooning, **7**, 241.
- Rubens, Peter Paul, was interested in the reproduction of paintings through copper engraving, **8**, 194.
- Ruby and its allies, the, **9**, 319.
- Rücker, Arthur William, permanent secretary, Royal Society of London, **5**, 17.
- Ruhmkorff, the electrical coil of, **6**, 199.
- Rumford, Count, and the vibratory theory of heat, **3**, 208; his experiments to determine the nature of heat, **3**, 209; determines that heat is a form of motion, **3**, 215; showed that labor may be transformed into heat, **3**, 255; founder of the Royal Institution of Great Britain, **5**, 30; challenged the doctrine of imponderable fluids as ap-

GENERAL INDEX

- plied to light and heat, **6**, 154; unsuccessful in his attempts to show that changes in chemicals are due to the action of heat rather than of light, **8**, 221.
- Rumsey, James, practical test of boat built by, **7**, 67.
- Rush, Dr. Benjamin, leader in reforms for care of insane, **4**, 245.
- Rust, early printer whose press was a modification of the Gutenberg press, **8**, 122.
- Rutherford, Professor, explains the presence of helium in radium, **5**, 105; and the instability of the atom, **5**, 110.
- SABBATICAL DAYS**, the four days in the month set apart for rest from work by the Assyrians, **1**, 65; the foundation of the Hebrew Sabbath, *ibid.*
- Sailing by dead reckoning, **7**, 14; explanation of, **7**, 15.
- Sails, used in antiquity by the Phœnicians, **6**, 62; used by the Egyptians, **7**, 56; modern sailing ships, **7**, 60.
- Saint-Hilaire, Etienne Geoffroy, the doctrine of transmutation championed by, **4**, 161.
- Saint, Thomas, inventor of an early type of sewing-machine, **9**, 89.
- St. Victor, Niepce, invented the glass negative from which photographic prints could be made, **8**, 229.
- Salerno, medical school at, **2**, 29.
- Saliva, its share in preparing food for absorption, **4**, 130.
- Salva, Don Francisco, telegraph invented by, **8**, 8.
- Sanborn, Edward H., his report on motive power appliances quoted, **6**, 73; article on *Motive Power Appliances*, **6**, 129.
- Sanctorius discovers "insensible perspiration," **2**, 187.
- Sandeman, quoted as to ancient versus modern methods of pottery-making, **9**, 249.
- Sanger-Shepherd, inventor of a single-lens camera, **8**, 238; his work in perfecting color-photography **8**, 239.
- Sans-pareil*, description of the famous locomotive bearing this name, **7**, 132.
- Santos-Dumont, the balloons of, **7**, 266.
- "Sarcode," the fluid contents of cells, **4**, 124.
- Sargon, Mesopotamian conqueror, his achievements recorded on a prism now preserved in the British Museum, **8**, 105.
- Saturn, the discovery of the inner rings of, by Bond and Dawes, **3**, 44; Maxwell's paper "On the Stability of Saturn's Rings," **3**, 45-48.
- Savannah*, the first steamship to cross the ocean, **7**, 73; description of the, **7**, 73.
- Savary, an astronomer of Paris, **3**, 58.
- Savery, Thomas, patented a steam engine to be applied to the raising of water, **6**, 85.
- Saw, modification of inclined plane, principle of, **6**, 55.
- Saxton, his name intimately connected with the early efforts at utilization of magneto-electric power, **6**, 178.
- Sayce, Professor Archibald Henry, on Chaldean superstitions, **1**, 70.
- Sayce, one of the inventors of the collodion-emulsion process, **8**, 231.
- Scandium discovered, **4**, 68.
- Scheele, Karl Wilhelm, oxygen and chlorine discovered by, **4**, 23; his discovery of chlorine, **4**, 25; believed in the phlogiston theory, **4**, 27; his many discoveries, **4**, 27, 28; experiments in the mysteries of respiration, **4**, 93; discovered the fact that certain chemicals quickly change

KEY AND INDEX

- color when exposed to light, 8, 220.
- Schiaparelli discovered that meteor swarms move in the orbit of a previously observed comet, 3, 55.
- Schilling, Baron, experiments with the telegraph, 8, 14.
- Schleiden, Dr. M. J., and the cell theory, 4, 118.
- Schlessinger, W. M., electric traction engine invented by, 6, 257.
- Schlick, Dr. Otto, records of the steadying effect of his gyroscope, 6, 128; his successful experiment with the gyroscope, 7, 219.
- Schmerling, Dr., fossil remains found by him in a cave in Westphalia rejected by Cuvier, 3, 103.
- Schmidt discovers the radioactive properties of thorium, 5, 100.
- Schoenlein, J. L., discovery of the cause of favus, 4, 208.
- Schools of physiological chemistry under guidance of Liebig and Wöhler in Germany and Dumas in France, 4, 128.
- Schultze, Max, studies in protoplasm, 4, 125.
- Schuman, Frank, "wire-glass" patented by, 9, 294.
- Schwann, Dr. Theodore, researches in animal cells, 4, 118; famous cell theory, 4, 119-122; discovered pepsin in gastric juice, 4, 129; studies in micro-organism, 4, 218; studies of the nerve tracts, 4, 258.
- Schwartz, the all-aluminum balloon constructed by, 7, 264.
- Schweigger, telegraph of, 8, 13.
- Science, Prehistoric, Chapter I, 1, 3.
- Science, Egyptian, Chapter II, 1, 25.
- Science of Babylonia and Assyria, Chapter III, 1, 56.
- Science, The Beginnings of Greek, Chapter V, 1, 103.
- Science, Greek, in the Early Attic Period, Chapter VII, 1, 139.
- Science, Post-Socratic, at Athens, Chapter VIII, 1, 178.
- Science, Greek, of the Alexandrian or Hellenistic Period, Chapter IX, 1, 189.
- Science of the Roman Period, Chapter X, 1, 253.
- Science, A Retrospective Glance at Classical, Chapter XI, 1, 285.
- Science in the Dark Age, Chapter I, 2, 3.
- Science, Mediæval, Among the Arabians, Chapter II, 2, 13.
- Science, Mediæval, in the West, Chapter III, 2, 31.
- Science, The Successors of Galileo in Physical, Chapter X, 2, 204.
- Science of Paleontology, The New, Chapter III, 3, 74.
- Science of Meteorology, The New, Chapter V, 3, 168.
- Science of Experimental Psychology, The New, Chapter IX, 4, 245.
- Science of Oriental Archæology, The New, Chapter X, 4, 287.
- Science, its effect upon industrial problems of to-day and tomorrow, 6, 316.
- Sciences, Two Pseudo—Alchemy and Astrology, Chapter VI, 2, 124.
- Scientific attitude of mind, the, 5, 230.
- Scientific Problems, Some Unsolved, Chapter VIII, 5, 203.
- Scientists, Philosopher, and New Institutions of Learning, Chapter IX, 2, 191.
- Scissors, lever of the first class, 6, 30.
- Scott, his suggestion to change the shape of the envelope of the balloon, 7, 248.
- Scott, Leon, produced what was known as a "phonautograph," 8, 93.
- Screw, an inclined plane, 6, 38.
- Scrope, G. Poulett, claimed that the highest mountains were

GENERAL INDEX

- masses of volcanic matter, **3**, 132; his theories of rock formations, **3**, 134.
- Sea-going steamships, **7**, 73.
- Seldon, Charles S., secured a patent designed to cover the use of the internal-combustion engine as a motor for road vehicles, **7**, 157.
- Semach, O. F., **9**, 179; designed the steel work for the Singer Tower, **9**, 179.
- Seneca, his silence regarding wind-mills makes their presence in Rome during his time problematical, **6**, 68; records that special fire guards watched the Roman house during entertainments, **9**, 150.
- Senefelder, Alois, invented lithography, **8**, 196; made various experiments in attempting to reproduce pictures for his writings, **8**, 198.
- Sennacherib, Mesopotamian conqueror; his achievements recorded on prisms now in the British Museum, **8**, 105.
- Serum-therapy, **4**, 240; the establishment of, **4**, 244.
- Serum treatment for serpent-poisoning, **5**, 184.
- Servetus, discoverer of pulmonary circulation, **2**, 168.
- Servinus, makes practical studies of effect of air in motion, his sailing car, **6**, 68; discovers law of pressure in all directions, **6**, 75.
- Seven Wise Men of Greece, **1**, 104.
- Severinus, Marcus Aurelius, Italian surgeon, **2**, 185.
- Sewage-disposal, the famous system of Berlin, **5**, 199; the system of the Parisians, **5**, 200.
- Sewing-Machine, The, Chapter IV, **9**, 87.
- Sewing-machine, what it has done for civilization, **9**, 87; the machine of Charles F. Weisenfhal, **9**, 89; the sewing-machine of Thomas Saint, **9**, 89; the first practical sewing-machine invented by Barthelémy Thimonnier, **9**, 90; mobs destroy the factory containing Thimonnier machines, **9**, 91; the American, John J. Greenough, invents a sewing-machine using a double-pointed reedle, **9**, 91; the sewing-machine of Walter Hunt, **9**, 92; the invention of Elias Howe, Jr., **9**, 93; description of his machine, **9**, 94; improvement on Howe's machine by John Bachelder, **9**, 96; improvement in mechanism of, by Allen B. Wilson, **9**, 96; Isaac M. Singer invents a new type of sewing-machine, **9**, 97; effect of sewing-machines upon manufactures, **9**, 99; machines adapted to various purposes, **9**, 101.
- Sextant, invention of the, **2**, 257; the development of, **7**, 18.
- Shackleton, Lieutenant, determined the location of the south magnetic pole, **7**, 13.
- Ships built of iron and steel, **7**, 74.
- Shoes, manufacture of. See Clothing the Extremities, **9**, 103.
- Shooting-stars, **3**, 55; the great shower of 1833, **3**, 171; the same in kind and origin as meteors, **3**, 172.
- Shovel, a modified form of the lever, **6**, 57.
- Sibu, whose contorted attitudes, according to Egyptian mythology, caused the irregularities of the earth's surface, **1**, 43.
- Signatures, doctrine of, **2**, 160.
- Siemens (with Halske) invented a lamp having a tantalum filament, **6**, 235; his experiments with electric motors, **7**, 181.
- Simpson, Sir J. Y., discovers the anæsthetic power of chloroform, **4**, 217.

KEY AND INDEX

- Singer, Isaac M., inventor of the modern type of sewing-machine, **9**, 97.
- Siphon recorder, invented by Lord Kelvin, **8**, 45.
- Sirius*, made a record transatlantic voyage in 1838, for the first time using steam alone as a motive power, **7**, 73.
- Skyscraper, *The Modern*, Chapter VII, **9**, 162; the development of, **9**, 162; the steel frame, **9**, 164; the problem of heating, **9**, 166; the invention of the Franklin stove, **9**, 167; steam adapted to heating, **9**, 168; the invention of the elevator, **9**, 169; new tools and new methods, **9**, 175; some thought-provocative statistics, **9**, 178.
- Sledge, a modified form of the lever, principle of the, **6**, 58.
- Slide-rule, engineer's, invented by Joshua Routledge, **6**, 120.
- Sloane's, Sir Hans, collection, purchased by British government, **5**, 4; finest of its kind in existence, **5**, 5.
- Small-pox, Jenner's discovery of inoculation for preventing, **4**, 190-196.
- Smith, William, and fossil shells, **3**, 74; his discovery that fossil rocks are arranged in regular systems, **3**, 75.
- Smith, Willoughby S., system of wireless telegraphy installed by, **8**, 51.
- Smyth, Piazzi, the idea of the gyroscope on ships first put into operation by, **7**, 217.
- Snell, Willebrord, discovers the law of refraction, **2**, 119.
- Societies, scientific, of the seventeenth century, **2**, 198.
- Solar and telluric problems, **5**, 205-213.
- Solubility, as explained by Ostwald and Mendelèef, **5**, 218-219.
- Some Physical Laboratories and Physical Problems, Chapter IV, **5**, 73.
- Some Medical Laboratories and Medical Problems, Chapter VII, **5**, 178.
- Some Unsolved Scientific Problems, Chapter VIII, **5**, 203.
- Somerset, Edward, describes his apparatus for raising water by expansion force of steam, **6**, 84.
- Sömmerring, telegraph of, **8**, 11.
- Sothic cycle measured by the heliacal rising of Sothis, **1**, 40.
- Sothis, the Egyptian name of the dog-star *Sirius*, the rising of which in the morning sky marked the beginning of the new year, **1**, 38.
- Soundings and Charts, **7**, 41.
- Southey, Hon. R., South-African colonial secretary, sent first South-African diamond to Paris Exposition, 1867, **9**, 316.
- Sovereign of the Seas*, *The*, description of, **7**, 60.
- Spallanzani, Lazzaro, rival of Hunter, **4**, 86; studies of spontaneous generation, **4**, 87; his chemical theory of digestion, **4**, 88; elaborates upon experiments of Réaumur, **4**, 89; theory of gastric juices, *ibid.*; experiments in mysteries of respiration, **4**, 93.
- Spark recorder, **8**, 45.
- Spectroscope, the, perfected by Kirchhoff and Bunsen, **3**, 62; **4**, 69; wonderful revelations of, **3**, 63; the results of the studies of Rutherford and Secchi, **3**, 64; what it reveals of the nature and condition of the stars, **3**, 65; it discovered the existence of "dark stars"; its power to record the actual motion of stars, **3**, 66; the speed of an invisible planetary body may be determined by it, **3**, 67; it determined the character and composition of the nebulae, **3**, 69; confirms the theory that meteorites and shooting-stars are one in kind and origin, **3**, 172; and

GENERAL INDEX

- photography, 4, 68-72; utility of, rendered complete, 4, 70; observation of the sun and stars by, 4, 71.
- Spencer, Herbert, his definition of science, 1, 3; lent his influence to the Darwin cause, 4, 175; belief in transmutation of species, 4, 176; and the disputed question of "spontaneous" variations, 4, 178; his *Principles of Psychology*, 4, 268.
- Spiller, invented a method of keeping photographic plates moist for several days, 8, 231.
- Spinning, primitive man's early efforts at, 9, 5; the modern methods of, epitomized, 9, 16; the preparation of wool for, 9, 18; Hargreaves and the spinning-jenny, 9, 21; Arkwright invents the water-frame, 9, 25; Crompton invents the mule, 9, 32; the self-acting mule, 9, 35.
- Spinning-frame. See Water Frame.
- Spinning-Jenny, the invention of, by James Hargreaves, 9, 22; defects of, 9, 25.
- Spinthariscopes, invented by Dr. Crookes, 6, 104.
- Sponge, investigations of, by Ernst Haeckel, 5, 155.
- "Spontaneous generation" of living protoplasm, 5, 223.
- "Spontaneous" variations, disputed question of, 4, 178.
- Sprague, Frank J., his work in developing electric railways, 7, 186.
- Sprott, detected the existence of glands in the mucous membrane, 4, 129.
- Spurzheim, Dr. Kaspar, propagandist of phrenology, 4, 248.
- Stahl, George Ernst, experiments with air, 4, 6; his phlogiston theory, 4, 7, 10; exponent of Animists' system, 4, 185.
- Staircases, ancient, 9, 155.
- Staite, W. E., his experiments with electric light, 6, 223.
- Stanhope, Earl of, produced a printing-press having a frame made of one piece of cast iron, 8, 122.
- Starley, brought the bicycle to the familiar form of the "safety," 7, 155.
- Stars, the fixed, 3, 57; distance of the, 3, 61; observation of the, by the spectroscope, 4, 71; study of the, by Lockyer, 5, 73; discovery of new, 5, 79, 80.
- Stas, M. J. S., his scientific views on photography, 8, 232.
- Static machine, principle of construction of, 6, 161.
- Steam, the age of, 6, 15; superheated, essential features of, 6, 114-115; high-pressure, Watt's antagonism to, 6, 112; experiments by Trevithick and Evans, 6, 113; much earlier general use in America, 6, 114; pressure of in cylinder in simple engine, 6, 118; in compound engine, 6, 118.
- Steamboat, early attempts to invent a, 7, 63; Fulton's final demonstration of its possibilities, 7, 70; the *Great Eastern* and her successors, 7, 77; the triumph of the turbine, 7, 81.
- Steam-engine, principle of, 6, 79-81; marks turning-point in history of civilization, 6, 81; development of, early experimenters and inventors (Hero, da Vinci, della Porta, de Caus, Marquis of Worcester, Savery, Branca, Papin, Newcomen), until time of Watt, 6, 82-92; limitations to Newcomen engine, 6, 93-94; Watt studies problem of condensation, 6, 95-97; his first revolutionary experiment and patent, 6, 97; description of his improvements up to 1769, 6, 98-99; rotary motion,

KEY AND INDEX

- how obtained, 6, 99-100; centrifugal governor, double-acting engine, cut-off, invented by Watt, 6, 102; high pressure advocated by Trevithick, compound engine invented by Hornblower, 6, 103; both ideas denounced by Watt, 6, 103; importance of Watt's inventions, 6, 104-106; persistence of walking beam, general use of, abandoned, 6, 110-111; use of high-pressure by Trevithick and Evans, 6, 112-114; theory of, worked out by Carnot and others, 6, 115; theory of, perfected by Clausius and Rankine, 6, 115; essential principles of operation, 6, 116; principle and invention of compound engine by Hornblower, revived by Woolf, 6, 117; advantages over simple engine, 6, 117-118; triple and quadruple expansion engine, chief use of, 6, 118; early belief in possibility of rotary engine, 6, 119; idea patented by Watt, 6, 119-120; rotary engine of Routledge, 6, 120-121; of Bell, 6, 121; model loaned to South Kensington museum by Fielding and Platt, 6, 122; the Hoffman rotary engine, 6, 123; possible future of, 6, 123; steam turbine, inventor of, 6, 124; description of Parsons' turbine engine, 6, 125; advantage of, 6, 126; largest steam turbine yet built, 6, 130.
- Steam Locomotive, The, Chapter IV, 7, 119; the "Oruktor Amphibious," constructed by Evans, 7, 121; the locomotive of Richard Trevithick, 7, 122; Brunton's remarkable locomotive, 7, 123; the experiments of Blackett, 7, 124; Stephenson solves the problem, 7, 124; the contest between the *Novelty*, the *Sanspareil*, the *Perseverance*, and the *Rocket*, 7, 131; the *Rocket* declared the winner, 7, 134; the *Globe*, 7, 134; Stephenson's *Planet*, 7, 135; improvements in recent years, 7, 135; some points of interest concerning the compound locomotive, 7, 138; the problem of keeping the fire-box supplied with coal, 7, 140; the Westinghouse Air-brake, 7, 141; automatic couplings, 7, 147; comparison between the *Rocket* and a recent type of locomotive, 7, 150.
- Steamship, ocean, equipped with turbine engines, 6, 124. (See Steamboat.)
- Steam shovel, use of in "open pit" mining, 6, 275.
- Steel, The Age of, Chapter XIII, 6, 271; boats used in transporting iron ore, 6, 280; machinery used in handling iron ore, 6, 282; conversion of iron ore into iron and steel, 6, 283; old method of manufacturing, 6, 287; Bessemer process of making steel, 6, 289; open-hearth method of making, 6, 294; alloy steels, 6, 295.
- Steelyard, a lever of the first class, 6, 30.
- Steinheil, Professor, assists in developing the first practical telegraph, 8, 17; experiments of, 8, 48.
- Stephenson, George, the success of his locomotive largely due to Trevithick's method of allowing the steam exhaust to escape into the funnel of the engine to increase the draught, 6, 114; solves the problem of steam locomotion, 7, 124; his early locomotives, 7, 126; the locomotive of 1825, 7, 127; description of his famous *Rocket*, 7, 133.
- Stereo-chemistry, 5, 219.
- Stethoscope, invented by Laennec, 4, 201.

GENERAL INDEX

- Stevens, Col. John, invented a rotary engine, 7, 69; a propeller steamboat produced by, 7, 69.
- Stevinus and the law of equilibrium, 2, 102; his horseless carriage, 2, 103; explanation of "hydrostatic paradox," 2, 104.
- Stirling, Dr., his efforts to utilize the expansion property of heated air in an engine, 6, 133.
- Stone Age, man knew certain rudimentary principles of science, 1, 5; the Egyptians of this age overthrown by an invading host, 1, 29.
- Storage-battery systems, 6, 194; 7, 188; Mr. Edison's new type of storage battery, 7, 190.
- Storm centre, merely an area of low barometric pressure, 3, 202; expansion of air through excess of temperature, 3, 203.
- Strabo, the most famous of ancient geographers, 1, 255; an investigator of details, not an original thinker, 1, 257; believed that a vessel could sail around the globe from Spain to India, 1, 260; his idea of the arrangement of the zones, 1, 262; his three fundamental principles, 1, 264.
- Street, Robert, suggested the use of inflammable gases as explosives, 6, 135.
- Strutt, Jedediah, inventor of a method of knitting a ribbed surface, 9, 56.
- Strutt, William, attempted to construct a self-acting mule, 9, 35; assisted Arkwright in constructing his first mill at Nottingham, 9, 27.
- Struve, F. G. W., discovered many double stars, 3, 58; discovered that many seemingly single stars are really clusters, 3, 59.
- Studies in the division of egg-cells, 5, 134, 135.
- Study of diseases in the Berlin Institute of Pathology, 5, 186-193.
- Sturgeon, constructed the first electric magnet, 6, 176.
- Submarine Cable, The, Chapter II, 8, 30.
- Submarine Vessels, Chapter III, 7, 93; first practical submarine boat made by David Bushnell, and details of its construction, 7, 94-98; Robert Fulton's experiments, 7, 98; Fulton's first submarine boat, the *Nautilus*, 7, 99; the attack on the *Argus* by Fulton's submarine, 7, 101; the attacks on the *Ramillies*, 7, 102; a successful diving boat, 7, 103; the sinking of the *Housatonic*, 7, 104; recent submarines and submersibles, 7, 105; the *Holland*, 7, 106; the Lake type of boat, 7, 108; the unsolved problem of marine navigation, 7, 110; present status, 7, 111.
- Submarine Signaling, 7, 83; early experiments with, 7, 86; practical application of, 7, 88.
- Successors of Galileo in Physical Science, The, Chapter X, 2, 204.
- Successors of Newton in astronomy, The, Chapter I, 3, 3.
- Suction, studied by early philosophers, 6, 64; explanation as pressure of external atmosphere given by Torricelli, 6, 65.
- Sulphuric ether, vapor of, pain-dispelling power of, 4, 209; Morton's use of, in dentistry, 4, 214; claims of Jackson and Long as to priority of discovery, 4, 215.
- Sulphurous gas liquefied, 5, 40.
- Sumerian, an alien civilized race, settled in Mesopotamia, overthrown later by Semitic invaders, 1, 60.
- Sun, the, observations of, by the spectroscope, 4, 71; study of,

KEY AND INDEX

- by Lockyer, **5**, 73; explanation of the continued heat of, **5**, 206, 207, 209; estimate of the heat-giving life of, **5**, 208; host of meteors falling into, **5**, 209.
- Sun-dial invented and perfected by Anaximander and Anaximenes, **1**, 109.
- Sun-spots discovered by Galileo, **2**, 79.
- Swan, J. W., an early experimenter with electric light, **6**, 228; filament for an incandescent lamp invented by, **6**, 233.
- Sydenham, Thomas, **2**, 188.
- Sylvius, founder of a medical system, **2**, 186.
- Symington, James, constructed a boat consisting of two hulls, with a paddle-wheel between them worked by steam, **7**, 67.
- Systems, medical, in the seventeenth century, **2**, 185.
- Szczepanik, Mr. Jan, his work in indirect color-photography, **8**, 245.
- TACITUS, tells us that in his day the Germans crouched in dens dug out of the earth, **9**, 133.
- Tagliacozzi, Gaspar, restores amputated noses, **2**, 183.
- Tait, Professor P. G., his apparatus for creating vortex rings in air, **3**, 291; molecules measurable in inches, **3**, 301; estimate of the heat-giving life of the sun, **5**, 208.
- Talbot, Fox, on Chaldean exorcisms, **1**, 71, 72; discovered a process of photographing on paper, called "Calotype" process, **8**, 227.
- "Task System" of manufacturing clothing. See Costumes.
- Taylor, in association with Miller and Symington, constructed a boat consisting of two hulls, with a paddle-wheel between them worked by a steam-engine, **7**, 67.
- Telegraph, development of, **8**, 3; early experiments with, **8**, 8; early experiments of Morse, **8**, 19; first public exhibition by Morse, **8**, 20; used for the first time, **8**, 21; multiple messages, **8**, 25.
- Telegraph, wireless. See Wireless telegraphy.
- Telephone, the development of the, **8**, 66; experiment of Hanksbee, **8**, 67; Robert Hooke's method of communication by, **8**, 68; "magic lyre" telephone invented by Sir Charles Wheatstone, **8**, 69; Bourseul suggests an electrical telephone, **8**, 71; practical telephones of Prof. Alexander Graham Bell and Elisha Gray, **8**, 73; Dr. Graham Bell describes his invention, **8**, 74; question of priority in the invention of the telephone, **8**, 81; improvement upon the type of receiver was made by Thomas A. Edison, **8**, 83; microphone transmitter invented by Emil Berliner, **8**, 83; other transmitters invented by Professor Hughes and Francis Blake, **8**, 84; long-distance telephone perfected, **8**, 84; solid back transmitter invented by A. C. White; **8**, 85; telephone equipment, **8**, 86; practical operation of the telephone, **8**, 87; automatic telephone systems, **8**, 87; the calling dial, **8**, 88; the wireless telephone, **8**, 88; Dr. Lee De Forest's connection with wireless telephony, **8**, 89; instruments used by Dr. DeForest, **8**, 90; advantage of wireless over wire telephones, **8**, 91.
- Telephone equipment, **8**, 85.
- Telescope, invented by Lipperhey, **2**, 78, 252; constructed by Galileo, **2**, 78, 253; Keplerian telescope, **2**, 253; Newton's reflecting telescope, **2**,

GENERAL INDEX

- 255; achromatic, invented, 2, 256.
- Telluric structure, the rigidity of, 5, 212.
- Telpherage systems, 6, 261.
- Temperature, 3, 302, 303, 305, 306; means employed to modify, 5, 201.
- Tennant's discovery of chloride of lime, 4, 26.
- Testu-Bressy, made a balloon ascension mounted on the back of a horse, 7, 242.
- Tetanus, discovery of toxine for, 4, 242.
- Teutonic*, one of the first twin-screw boats to make ocean records, 7, 81.
- Textiles, The Manufacture of, Chapter II, 9, 38.
- Textiles, finishing textile fabrics, 9, 52; printing patterns on the finished cloth, 9, 52; finishing woollen goods by "teasing," 9, 54; lace-making and knitting machinery, 9, 55; modern origin of knitting and crocheting, 9, 55; knitting-machine invented by Rev. William Lee, 9, 56; Jedediah Strutt's invention of a machine for knitting a ribbed surface, 9, 56; Peter Claussen invents a circular knitting-machine, 9, 56; the "latch needle" introduced by M. Townsend, 9, 57.
- Thales the Milesian, foretold the eclipse which stopped a battle between the Lydians and the Medes, 1, 103; one of the Seven Wise Men of Greece, 1, 104; a link connecting the learning of the old Orient with the scholarship of the new Occident, 1, 105; predicted the great eclipse, 585 B.C., 1, 106; the father of Greek astronomy, 1, 106; a primitive geometer, 1, 107; is credited with five geometrical truths, 1, 108; inventor of science of triangulation, 1, 108; thought the eclipse of the sun a purely natural phenomenon, 1, 109; a pioneer philosopher of the West, 1, 115.
- Theophrastus, did for the vegetable kingdom what Aristotle did for the animal, 1, 188; his work on the mineral kingdom is the most notable that was produced in antiquity, *ibid*.
- Theory, The Phlogiston, In Chemistry, Chapter I, 4, 3.
- Theories, Modern, of Heat and Light, Chapter VI, 3, 206.
- Theories of Organic Evolution, Chapter VI, 4, 140.
- Thermometer invented by Galileo, 2, 119.
- Thimonnier, Barthelémy, inventor of the first practical sewing-machine, 9, 90.
- Thinite dynasty, the first, 1, 36.
- Third rails and trolleys, 7, 184.
- Thirteenth-century medicine, 2, 33.
- Thompson, Benjamin (Count Rumford), an American, founder of the Royal Institution of Great Britain, 5, 30; his experiments to demonstrate the vibratory theory of heat, 3, 208.
- Thompson, Sir J. J., and the nature of electricity, 5, 92-97; and the source of energy of radio-activity, 5, 107; his hypotheses of the instability of the atom, 5, 109; his conception of the electron, 6, 158.
- Thompson, R. Campbell, his studies of the astronomical tablets of the Assyrians, 1, 64; thought the Chaldean astronomers had a kind of machine for reckoning time, 1, 67.
- Thomson, Thomas, adopted the atomic view of Dalton, 4, 44.
- Thomson, Sir William. See Lord Kelvin.
- Thoria, its use in making gas mantles, 6, 211; used in connection with zirconia, alumina, magnesia, etc., in making gas mantles, 6, 211.

KEY AND INDEX

- Thorium, discovery of the radioactive properties of, **5**, 100.
- Thundering Legion, the, **1**, 296.
- Tisandier brothers applied the electric motor to a balloon, **7**, 264.
- Tolstoi, Count Leo, his fondness for physical work an eccentricity, **6**, 27.
- Tongs, lever of the third class, **6**, 31.
- Tools, man the tool-making animal, **6**, 6-8.
- Torricelli, disciple of Galileo, **2**, 120; discovers that "suction" is air pressure, **2**, 120; **6**, 65; his barometer, **2**, 122; discovery in hydraulics, **2**, 123.
- Townsend, M., inventor of the "latch needle" for knitting-machines, **9**, 57.
- Toxine, anti-, the discovery of, for tetanus and diphtheria, **4**, 242.
- Transformers, electrical, **6**, 198.
- Transmission of power, by means of gears, belts, chains, **6**, 35; by electricity, **6**, 194.
- Transmutation of species, **4**, 149, 150, 152, 153, 159, 161, 167, 170, 174, 176.
- Treadle, lever of the third class, **6**, 31.
- Treadmill, modified form of lever, **6**, 58.
- Treviranus, Gottfried Reinhold, motion of cell contents, rediscovered in 1807 by, **4**, 124; coined the word "biology," **4**, 160.
- Trevithick, Richard, his pumping-engines, used by Boulton and Watt, introduces high-pressure engine, introduces steam-propelled road vehicles, **6**, 113; planned an iron ship, **7**, 75; the locomotive of, **7**, 121; the automobile of, **7**, 159.
- Trichina spiralis*, Owen's discovery of, **4**, 207.
- Trichinosis, the subject of, **4**, 207.
- "Trophic centres," Waller and the study of, **4**, 280.
- Trotula, a perhaps mythical woman physician, **2**, 29.
- Trowbridge, Prof. J., experiments relating to the transmission of messages by wire, **8**, 49.
- Tucker, Stephen D., invented a rotating folding cylinder that folded papers as fast as the presses could print them, **8**, 130.
- Tungsten lamp, **6**, 234.
- Tungsten steel, **6**, 297.
- Tuke, Dr. William, leader in reforms for care of insane, **4**, 245.
- Tunis, Howard Hansel, satisfactory monorail system invented by, **7**, 193.
- Turbine steam-engine, first proposed by Branca (1629), **6**, 87; Mr. C. A. Parsons' invention of, **6**, 124; its use on the *Turbinia*, **6**, 124; its application to ocean steamers, **6**, 125; detailed description of, **6**, 126; its efficiency as compared to reciprocating engine, **6**, 126; estimate of, by the *London Times*, **6**, 127; as used on *Lusitania*, **6**, 128; its use in America as reported by Mr. Edward H. Sanborn, **6**, 129; its use in foreign countries, **6**, 130; of Dr. Gustav De Laval, **6**, 131; the use of, on ocean steamers, **7**, 82.
- Turbine water-wheels, invention of; replaces earlier types of water-wheels, **6**, 72; new types of, **6**, 73; used in generating electricity at Niagara Falls, **6**, 187.
- Turbinia*, first steamship equipped with turbine engine, 1897, **6**, 124; its speed astonished the nautical world, **7**, 81.
- Turner, James, invented "Turner's yellow," **8**, 283.
- Turpin, studies of micro-organism, **4**, 219.

GENERAL INDEX

- Two Pseudo-Sciences**—Alchemy and Astrology, Chapter VI, 2, 124.
- Tycho Brahe**, great Danish astronomer, 2, 65; observation of comets, 2, 67; method of finding latitude, 2, 68; re-discovery of "moon's variation," 2, 69; explanation of the new star in Cassiopeia, 2, 69.
- Tyndall, John**, a recruit to the Darwinian theory, 4, 175; corroborates the results of Pasteur as to the non-existence of spontaneous generation, 4, 180.
- UNIVERSITIES** in the thirteenth century, 2, 43.
- University College, London**, Dr. Ramsay's labors in, 5, 82.
- University of Jena**, 5, 148-150; freedom of thought and expression at, 5, 158.
- Unsolved Scientific Problems**, Some, Chapter VIII, 5, 203.
- Uranium**, discovery of the radioactive properties of, 5, 100.
- VALVES** of the veins, controversy about them in the sixteenth century, 2, 166.
- Van Beneden**, discovery of the centrosome, 5, 226.
- Van Berquen**, his discovery that by a certain arrangement of the facets on a diamond the reflection and dispersion of light are greatly increased, 9, 305.
- Van Depoele**, the inventions of, 7, 185.
- Van Helmont, Jan Baptista**, founder of medical system, 2, 185.
- Van 't Hoof's** studies of the space relations of atoms, 5, 219.
- Van Niekirk, Schalk**, part taken in the discovery of South African diamonds, 9, 315.
- Van Siegen**, invented the form of metal-engraving known as mezzotint, 8, 196.
- Varley**, constructed a dynamo-electric machine, 6, 178.
- Varnishes**, 8, 316.
- Vauconson, M.**, a Frenchman who suggested plans for a power-loom, 9, 43.
- Vegetables**, respiratory organs of, 4, 94; cell walls of, 4, 124.
- Ventilation**, problems in, 5, 200; in mines, 6, 253.
- Venus**, phases of the planet discovered by Galileo, 2, 79.
- Verneuil, M.**, his experiments with artificial gems, 9, 332.
- Vesalius, Andrew**, "the greatest of anatomists," 2, 164.
- Ville de Orléans**, the famous voyage made by the, 7, 259.
- Vinci**, see Leonardo da Vinci.
- Viper**, wrecking of, possibly caused by gyroscopic action, 7, 222.
- Virchow, Rudolf**, demonstrates the correctness of Von Mohl's cell formation, 4, 127; the discoveries of, 5, 188; his work in pathology, 5, 189; his ways of living and working, 5, 190; his method of teaching, 5, 191, 192.
- Vitalists' system**, 4, 185; theory of, 4, 186.
- Vitruvius**, warns the Romans against elaborately carved cornices, 9, 150.
- Volta, Alessandro**, inventor of the "voltaic pile," 3, 230; his discovery paved the way for the electric light, 6, 220.
- Voltage**, theoretical explanation of high and low, 6, 200.
- Von Alteneck**, introduced drum arrangement of armature, 6, 179.
- Von Baer, Karl Ernst**, studies in embryology, 4, 122.
- Von Empergnier**, discovered that metal embedded in concrete is protected from rust, 9, 198.
- Von Guericke, Otto**, inventor of air-pump, 2, 211; demonstration of atmospheric pressure by the striking experi-

KEY AND INDEX

- ment with the "Magdeburg spheres," 2, 212; 6, 66; electrical discoveries, 2, 213.
- Von Kleist, Dean, discovers principle of the Leyden jar, 2, 280.
- Von Mohl, Dr. Hugo, studies of the vegetable cell, 4, 123; discovery of the formation of cells, 4, 126; correctness of cell theory demonstrated by Virchow, 4, 127.
- Vortex atom, speculations based upon the hypothesis of, 5, 216.
- Vortex theory, Lord Kelvin's estimate of, 5, 217.
- Vulcan*, the pioneer of all iron boats, built by Thomas Wilson, 7, 75.
- WALES, observed fluctuation of the compass due to the magnetic influence of the ship on which it is placed, 7, 11.
- Walking-beam, persistence of, in engines, 6, 102, 110; use in side-wheel steamers, general use abandoned, 6, 111.
- Wallace, Alfred Russel, the work of, 4, 172; joint paper of, and Darwin presented to the Linnæan Society of London, 4, 173.
- Wallace, Sir William, his clansmen the prototypes in military costume of modern Scotch soldiers, 9, 75.
- Waller and the study of "trophic centres," 4, 280.
- "Warren mastodon," 3, 113.
- Wars, their stimulating effect upon surgery in the thirteenth century, 2, 39.
- "Washington" press, the popular hand-press for taking fine proofs, 8, 122.
- "Water controversy" between Cavendish and Watt, 4, 14, 15.
- Water, weight of cubic foot, working capacity determined, 6, 70; law of pressure in all directions discovered by Servinus, 6, 75; as a conductor of electricity, 8, 48.
- Water engines, described, 6, 77-78.
- Water-frame, invented by Richard Arkwright, 9, 25; principle of its construction, 9, 26.
- Watermills, early history of, 6, 70.
- Water motor, design proposed by Lord Armstrong, efficiency of, 6, 121.
- Water-wheels, types of, use of, 6, 71; recent advances in, 6, 73.
- Watson, William, electrical experiments, 2, 284; discovered that water could be made to take the place of wires as the return circuit of two batteries, 8, 48.
- Watson, Thomas A., assisted Dr. Bell in his experiments with the telephone, 8, 80.
- Watt, James, controversy with Cavendish, 4, 14; Arago decides in favor of, 4, 15; his process of practical bleaching, 4, 26; perfector, not inventor, of steam-engine, 6, 82; early life; connection with Professor Black, 6, 94; studies deficiencies of steam-engine, 6, 94-97; first revolutionary experiment, first patent, 6, 97; describes his improvements up to 1769, 6, 98-99; second patent with device for reciprocating motion, 6, 99; Picard's patent of crank and connecting rod leads to invention of sun-and-planet gearing, 6, 100; partnership with Boulton in engine building, 6, 100-101; invents centrifugal governor, 6, 102; invents double-acting engine and cut-off, 6, 102; denounced ideas of high pressure, and compound engine; antagonistic to steam locomotion, 6, 103; importance of his inventions, 6, 104-106; personality of, 6, 107-109; fails to see feasibility of doing away with walk-

GENERAL INDEX

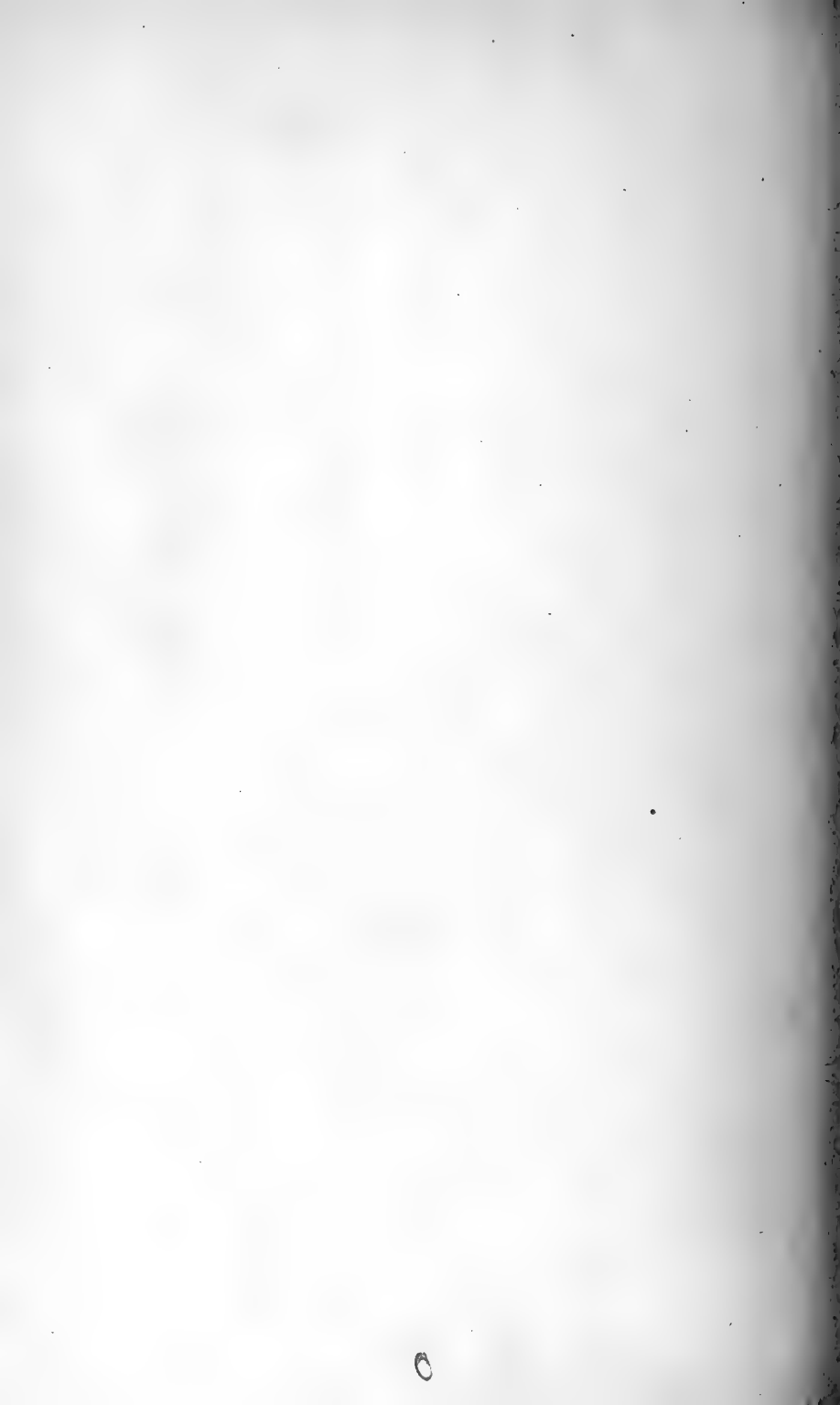
- ing-beam, 6, 111; antagonism to high pressure considered, 6, 112; patented idea of rotary engine, 6, 110-120.
- Weaving, the art as practised by primitive races, 9, 39; how the Egyptians may have learned the art, 9, 39; the dependence of weaving upon spinning, 9, 41; John Kay invents the flying shuttle, 9, 42; the power-loom invented by Dr. Cartwright, 9, 44.
- Weber, E. H., experiments on nerve stimuli, 4, 264.
- Weber, one of the first inventors of a practical working telegraph, 8, 17.
- Wedge, an inclined plane, 6, 38; modifications of, 6, 54.
- Wedgwood, Josiah, gauged the highest temperature with the clay pyrometer, 3, 206; the superiority of his pottery explained, 9, 232.
- Wedgwood, Thomas, his application to picture-reproduction of Scheele's discovery that light changes the color of certain chemicals, 8, 221.
- Weisenthal, Charles F., invented a sewing-machine for sewing hand-embroidery, 9, 89.
- Weismann, August, objections to the Lamarckian conception that acquired characters are transmissible, 4, 178; theory of heredity, 5, 134; scheme of the relations of the intracellular units, 5, 226.
- Wellington, Duke of, his opposition to the development of the automobile, 7, 160.
- Wells, Dr. Horace, experiments in painless dentistry, 4, 213.
- Wells, Dr. W. C., solved the problem of dew formation 3, 183; his essay on dew, 3, 185.
- Welsbach, Dr. Auer von, his invention of the incandescent gas burner, 6, 210.
- Werner, a scientist of Saxony, 3, 131; made the earliest conspicuous attempt to classify the earth's strata, 3, 155.
- Westinghouse, George, inventor of the Westinghouse air brake, 7, 141.
- Wheatstone, Sir Charles, his name intimately connected with the early efforts at utilization of magneto-electric power, 6, 178; invented the "magic lyre telephone," 8, 69.
- Wheel, lever of the first-class, 6, 33; primitive friction reducer, 6, 55; speculation as to invention of, 6, 56.
- Wheelbarrow, lever of the second class, 6, 30.
- Whistler, one of the great exponents of the form of engraving known as etching, 8, 196.
- White, C. A., invented the "solid back" transmitter, 8, 85.
- Whitney, Eli, inventor of the cotton-gin, 9, 9; early life of, 9, 9; circumstances leading up to his invention of the cotton-gin, 9, 10; difficulties attending the patenting and marketing of his invention, 9, 11.
- Wilcox, James, the balloon ascension of, 7, 237.
- Wilde, Dr. Henry, inventor of the first separately excited dynamo, 6, 178.
- Wilkinson, assisted in clearing up the mysteries of the inscriptions on the Rosetta Stone, 1, 27.
- Willis, Thomas, English physician, 2, 187.
- Wilson, Allen B., improves the mechanism of the sewing-machine, 9, 97.
- Wilson, Thos. F., his discovery of acetylene gas, 6, 213.
- Wilson, Thomas, built the first iron vessel, 7, 75.
- Windlass, a lever of the second class, 6, 34.
- Windmills, described, history of,

KEY AND INDEX

- 6, 68; difference between modern and ancient; defects of, 6, 69.
- Winds, controlled by a general mathematical law, 3, 200; their direction in a storm centre, 3, 201, 202; long-time forecasts possible only in India, 3, 205.
- Winkler, Johann Heinrichs, tries to measure speed of electric current, 2, 278.
- Wireless telegraph, used by Cyrus the Great, 8, 3; the oldest form of communication by telegraph, 8, 3; use of, by Napoleon, 8, 3; electrical, 8, 47; water and earth as conductors, 8, 48; discoveries of Professor Trowbridge, of Harvard, 8, 49; experiments of Sir William H. Preece, 8, 50; system patented by Thomas A. Edison, 8, 50; system of communication installed by Smith and Granville, 8, 51; experiments with "Hertzian Waves," 8, 52; "coherer" invented by Dr. Branly, 8, 52; the work of Marconi, 8, 54; "tuning" the messages, 8, 57; first trans-Atlantic message, 8, 61; the DeForest system used during the Russo-Japanese war, 8, 65; other systems, 8, 65.
- Wireless telephone, 8, 89; instruments used by Dr. Lee DeForest, 8, 90; advantage of wireless over wire telephones, 8, 91.
- Wise, John, his record flight in a balloon, 7, 256.
- Wiseman, Richard, English surgeon, 2, 184.
- Wöhler, Friedrich, synthesized the organic product urea, 4, 54; isomerism proved by, 4, 62; school of physiological chemistry under guidance of, 4, 128.
- Wolff, Henry, contemporary engraver, methods differ little intrinsically from those of early wood engravers, 8, 187.
- Wollaston, Dr. William Hyde, his suggestions to improve the microscope, 4, 110.
- Women, the bearers of burdens, 6, 56.
- Wood-engraving, 8, 184; the oldest wood-cuts, 8, 186; improvement made by Dürer, 8, 188; technic of wood-engraving, 8, 189; time and cost of production, 8, 191.
- Woodhouse, Sir Philip, Governor of Cape Colony, purchased first important South African diamond, 9, 316.
- Wool, the preparation of, for spinning, 9, 18.
- Woolf, Arthur, revived idea of compound engine, 6, 117; demonstrated its merits over simple engine, 6, 117.
- Woolrich, his name intimately connected with the early efforts at utilization of magneto-electric power, 6, 178.
- Worcester, Marquis of. See Somerset, Edward.
- Work, definition of, 6, 29.
- Wortley, Col. Stuart, his work in photography, 8, 232.
- Wortman, Dr. J. L., his evidence in connection with the fossil lineage of the edentates, 3, 114.
- Wright, Orville (with his brother Wilbur), invented the flying-machine, 7, 288; his flights near Washington in an attempt to fulfill the Government tests, 7, 295; his flights at Berlin, 7, 295.
- Wright, Wilbur (with his brother Orville), invented the flying-machine, 7, 288; his series of flights in France, 7, 293; his sensational flight up the Hudson from Governor's Island, 7, 295.
- Wundt, Dr. Wilhelm, studies of sensations, apperception, and volition, 4, 267.

GENERAL INDEX

- Wyoming*, the largest schooner ever constructed, **7**, 61.
- XENOPHANES**, founder of the famous Eleatic School, **1**, 114, 127; his theories concerning the creation, **1**, 128; the earliest paleontologist, **1**, 120.
- Xiphilinus, his account of the battle between the Romans and the hostile Quadi, **1**, 297.
- X-ray, discovered in 1895, **5**, 97.
- Yankee*, experimental attacks upon, by submarines, **7**, 116.
- Yersin, famous for his researches in the prevention and cure of cholera, **5**, 184.
- Young, Dr. Thomas, and the wave theory of light, **3**, 215-225; his extraordinary precocity, **3**, 216; his "theory of light and colors," **3**, 217; his experiments with micrometers, **3**, 222; his doctrine of the interference of undulations, **3**, 223; his wave theory endorsed by Fresnel and Arago, **3**, 226; determined opposition to his wave theory by French scientists, *ibid.*; final acceptance of his wave theory by the French academy, **3**, 227; his theories about ether, **3**, 285; decipherment of the Rosetta Stone, **4**, 290; professor of natural history in Royal Institution, **5**, 35; wave theory of light, **5**, 36; his interpretation of Franklin's theory of electricity, **6**, 150.
- ZENKER**, his theory on color-photography, **8**, 236.
- Zenon, discovery of, **5**, 87.
- Zeppelin, Count, the dirigible balloons of, **7**, 265.
- Zero, absolute, approach to the, **5**, 69; probable form of all matter at, **5**, 70.
- Zoological classification, Professor Haeckel's work in systematizing, **5**, 168.
- Zoology at the close of the eighteenth century, **4**, 99.
- Zoology, Ernst Haeckel and the New, Chapter VI, **5**, 144.
- Zoology, the new, Ernst Haeckel and, **5**, 144; import of the study of, **5**, 166; fundamental conception of, **5**, 167; Haeckel the recognized leader in, **5**, 171.





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